DOCUMENT RESUME

ED 135 340 IR 004 374

AUTHOR	King, D. W.; And Others
TITLE	Statistical Indicators of Scientific and Technical Communication (1960-1980) Volume I: A Summary Report.
INSTITUTION	King Research, Inc., Rockville, Md.
SPONS AGENCY	National Science Foundation, Washington, D.C. Div. of Science Information.
PUB DATE	20 Dec 76
CONTRACT	NSF-C87
NOTE	97p.; For related document, see IR 004 321
AVAILABLE FROM	Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (Stock Number 038-000-00295-3, $2.05)
EDRS PRICE	MF-$0.83 HC-$4.67 Plus Postage.
DESCRIPTORS	Administration; Comparative Statistics; *Information Dissemination; Management; Publications; Scientific Enterprise; Statistical Data; *Statistical Surveys; Tables (Data); *Technical Reports
IDENTIFIERS	*Indicators; *Scientific and Technical Information

ABSTRACT

This report represents the first year of an effort to develop a system of indicators of scientific technical information. It examines the growth of scientific books, journals, reports, patents, and dissertations and is directed toward helping planners and policymakers evaluate the status of scientific and technical communication in the nation. Other growth trends covered include the number of scientific and technical book titles, copies sold per book title, and revenue per title. The report is heavily illustrated with graphs and charts, and data are presented for intervals of one year beginning with 1960. The framework leading to the system of the above statistical indicators and the analysis of data are presented in a second volume (IR 004 321). (Author/DAG)

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STATISTICAL INDICATORS OF SCIENTIFIC AND TECHNICAL COMMUNICATION 1960-1980

Volume 1

A Summary Report

For:

NATIONAL SCIENCE FOUNDATION

Division of Science Information

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IR004374

FOREWORD

This report is based on the first year of research supported by the Division of Science Information of the National Science Foundation. It provides an analytical summary of data on scientific and technical information (STI), beginning with the generation of STI through its use. We expect to continue efforts to refine, expand, and improve measures of scientific and technical communication. Therefore, your suggestions and comments on this report will be appreciated.

Details underlying data included in this report are available in Volume II of this series, currently available from NTIS.[1]

Lee G. Burchinal
Director
Division of Science Information
National Science Foundation

[1] *Statistical Indicators of Scientific and Technical Communication (1960-1980), Volume II: A Research Report*, May 1976, King Research, Inc., PB 254 060, $12.75 for paper copy; $2.25 for microfiche.

PREFACE

The National Science Foundation, Division of Science Information, places major importance on supplying data and statistical indicators that can be used for planning and policy purposes. Thus, NSF requested proposals for developing statistical indicators in the scientific and technical information (STI) field. The justification for developing these indicators is quoted from the Request for Proposal E-77 as follows:

> Numerous studies have focused on the transfer of research results from originators to users. But most of these investigations have been limited to one phase of information transfer or to one field of science or to one point in time. The need for a comprehensive and continuing information base for policy and planning is by no means new, but it becomes even more urgent as the volume of scientific and technical information rises beyond the reach of manual processing, while automation on a massive scale approaches the point of economic feasibility. In order to monitor and assess these developments, a statistical system for gathering, organizing, and analyzing data relevant to all aspects of scientific and technical communication is indispensable. The objective of this project is to develop and initiate a system of statistical indicators of scientific and technical communication. Each indicator, as a time series, will trace out some aspect of the production of new scientific and technical information, of the transfer of that information to users, or of the resources needed to preserve it for future use and to retrieve it when needed. The indicators are intended for analysis and interpretation by planners and policymakers in Government and in the private sector and as data in modeling and simulation studies. Taken together they can be used to describe trends, anticipate new developments, and guide the evolution of the Nation's information resources toward better and more economical service.

In order to develop a system of statistical indicators, it was necessary to study hundreds of secondary data sources and, from these sources, derive a small number of indicators that portray the direction of scientific and technical (S&T) communication over the past and into the future. It is anticipated that these indicators will be useful to information science administrators and policymakers as well as others engaged in the management of STI.

Since the range of available data is so broad and since the data are interwoven into a small number of indicators in diverse ways, we have chosen to present results of our investigation in three distinct volumes.

- This, the first volume, is a presentation of the *Statistical Indicators of Scientific and Technical Communication (1960-198*. This volume includes a description of th major indicators and their significance to the field of communication of STI. These indicators are addressed to information managers, administrators and policymakers.
- The second volume is titled *Statistical Indicators of Scientific and Technical Communication (1960-1980): A Research Report*, and concerns the analysis of data leading to the system of statistical indicators. It includes a description of the framework leading to the system of statistical indicators. The second volume will be of interest to those engaged in research involving communication of STI. It will also serve those who are interested in the details of how the system of statistical indicators was derived.
- The third volume is a data appendix to Volume II. It contains the "raw" data which we collected in the course of the study. It is hoped that this volume will be of use as a data reference tool to those engaged in detailed research in communication of STI.

One of the constraints of the study was that all data be of a secondary nature, (that is, information obtained from existing and available data sources). Thus, we attempted an exhaustive analysis of secondary sources of data, and their weaknesses and strengths, in building a system of statistical indicators. A second constraint of the study was that the number of statistical indicators be not less than five nor more than twenty.

The study, designed by King Research, Inc., Center for Quantitative Sciences, included five major tasks—a background study, development of a framework for the indicators, data collection, development of the system of statistical indicators and reporting.

Ms. Helene Ebenfield, the project monitor, has been most helpful and supportive throughout the entire project. In addition to the identified authors, other professional staff members of the Center for Quantitative Sciences who were heavily involved in the study were Katherine McEvoy, Alice Newman, Colleen Schell, Charles Schueller, and Mary Yates. Mr. F. W. Lancaster, a consultant on the project was of particular help in the preparation of the research report (Volume II). Other consultants on the project were Francois Kertesz, Klaus Otten, William Creager and Betti Goldwasser. We also received substantial help from a large number of voluntary reviewers and organizations. Mr. Robert Cotten assisted in editing this volume and Volume II.

Donald W. King
Principal Investigator

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Chapter 1

Introduction

Chapter 1
Introduction

BACKGROUND

Communication of scientific and technical information (STI) is clearly one of the most important aspects of scientific research, for it is this process that leads to its widespread use and ultimate benefits. Communication, however, has become increasingly difficult and complex as the number of persons engaged in science and technology (S&T) multiplies, as the breadth and depth of scientific knowledge grows correspondingly and as the need for multidisciplinary scientific research becomes more prevalent in such critical areas as cancer and energy research. Scientific and technical communication currently consists of numerous formal and informal media ranging from books to unrecorded word of mouth. These media are transferred from author to user through a myriad of channels utilizing hundreds of processes. The difficulties encountered in S&T communication are further aggrevated by increased costs of the communication processes coupled with decreased resources available for performing the communication functions. Also adding some confusion to the state of S&T communication are a number of recent and potential technological innovations that may be applied to the various steps of the communication process if they are demonstrated to be technologically sound and economically feasible. Thus, S&T communication could go in any one of several dramatic new directions in the future.

Unfortunately, to date there is no cohesive set of data that measures the extent of communication by the various media or by the channels used to transfer STI. Furthermore, there are no data indicating the amount of labor resources and funds expended in communicating S&T information. Because of a lack of such fundamental information concerning communication processes, it is extremely difficult to know what directions to pursue concerning information research and technology or to speculate as to which innovations or technologies hold the most promise in solving the complex problems that must be faced in the future

In order to gain some understanding of what has happened and to anticipate what is likely to occur in the future, a system of statistical indicators of S&T communication was needed. This led to the primary objective of the research of this monograph which was to develop such a system of statistical indicators based on available secondary sources of data. Since data were largely limited to secondary sources and several gaps in data were filled by extending data on the basis of assumptions, there are some weaknesses in the system of indicators. These weaknesses and assumptions are discussed in detail, along with methods of data collection and analysis in *Volume II: A Research Report.*

It is emphasized that we chose to provide as complete and comprehensive picture of the S&T communication in the United States as possible without making assumptions that do not have some reasonable basis. If one believes the assumptions used to be invalid, data based on other assumptions can be incorporated into the indicator models to determine their impact on conclusions that are drawn from the system of indicators. Finally, if secondary sources or assumptions are sufficiently weak, the collection of new, more accurate and precise data may be warranted. Thus, this statistical indicators report will also serve a useful purpose in determining future data requirements.

Data collection in this study involved a large number of secondary sources. Among these, various National Science Foundation, Bureau of Census, and Bureau of Labor Statistics publications provided information on scientific manpower and research and development (R&D) funding patterns, and survey results from the Library Surveys Branch of the National Center for Educational Statistics were used in discussions of libraries. Both *Statistical Abstracts of the United States*[3]

and the *Bowker Annual of Library and Book Trade Information*[2] are heavily cited throughout the study.

In the important area of journal publishing, a valuable source was the SATCOM report[5] prepared by the Task Group on the Economics of Primary Publication of the Committee on Scientific and Technical Communication of the National Academy of Sciences and the National Academy of Engineering. This report presented results of a study, prepared by Conyers Herring, that carefully analyzed a number of economic factors of journal publishing such as costs, price, circulation, and sources of revenue.

Additional data on journals came from a study sponsored by the National Science Foundation, Division of Science Information. This study[4], recently completed by the Indiana University under the direction of Bernard M. Fry, obtained economic data from journal publishers and libraries for three years over a five year period (1969, 1971, 1973). Our results use some of these data, as well as data from other sources, to extend the analysis back to 1960 and to forecast some statistical indicators of the economics of journal publishing forward to 1980. A second study sponsored by NSF is currently underway at New York University under the direction of Dr. Fritz Machlup.[6] This study will provide accurate and up-to-date data on publishers, for a 10-year period, including costs, price and circulation. We expect that some of our data will be superseded by these data since their data gathering procedures (data collection with personal interview by graduate students) are superior to procedures used by others in the past.

Another data source was a special study of journal publishing conducted to fill a major gap in the available secondary data sources. This study was subdivided into three distinct parts. The first part involved a sample of 191 scholarly S&T journals. These journals were visually examined back to 1962 to obtain information about their physical characteristics such as number of issues per year, number of articles per issue, number of pages per article, number of characters per page, number of special graphics, and number of citations. The second part involved a survey of authors of journal articles to determine information about their articles such as page charges, reprints distributed and number of manuscript revisions. Information was also obtained about journal articles that were cited by the authors such as how the authors identified their cited articles and how they gained physical access to them. The third part of the study involved a thorough review of secondary sources of data such as other studies, and available publisher records. Initial plans called for a small publisher survey, but it was decided that this survey would be duplicative of Machlup's research previously referenced. The journal tracking study provided information over the 1962 to 1974 period on the prices charged to various subscribers. There is a dearth of information on publishing costs over this period of time. Therefore, a cost model developed in an earlier NSF study[1] was applied to estimate costs of typical journals.

To the extent possible, all data collection was conducted in terms of fields of science used by the National Science Foundation and by the Office of Management and Budget.[1] These nine fields are:

1. Physical Sciences (Astronomy, Chemistry, Physics, Physical Sciences)
2. Mathematics (and Statistics)
3. Computer Sciences and Engineering
4. Environmental Sciences (Atmospheric Sciences, Geological Sciences)
5. Engineering (Aeronautical, Astronautical, Chemical, Civil)
6. Life Sciences (Biological, Clinical Medical, Other Medical, Life Sciences)
7. Psychology (Biological Aspects, Social Aspects, Psychological Sciences)
8. Social Sciences (Anthropology, Economics, History, Linguistics, Political Science, Sociology, Law, Social Sciences)
9. Other sciences (Science and Technology Assessment, Science Policy, Other Sciences)

The overall framework used for analysis is briefly discussed below.

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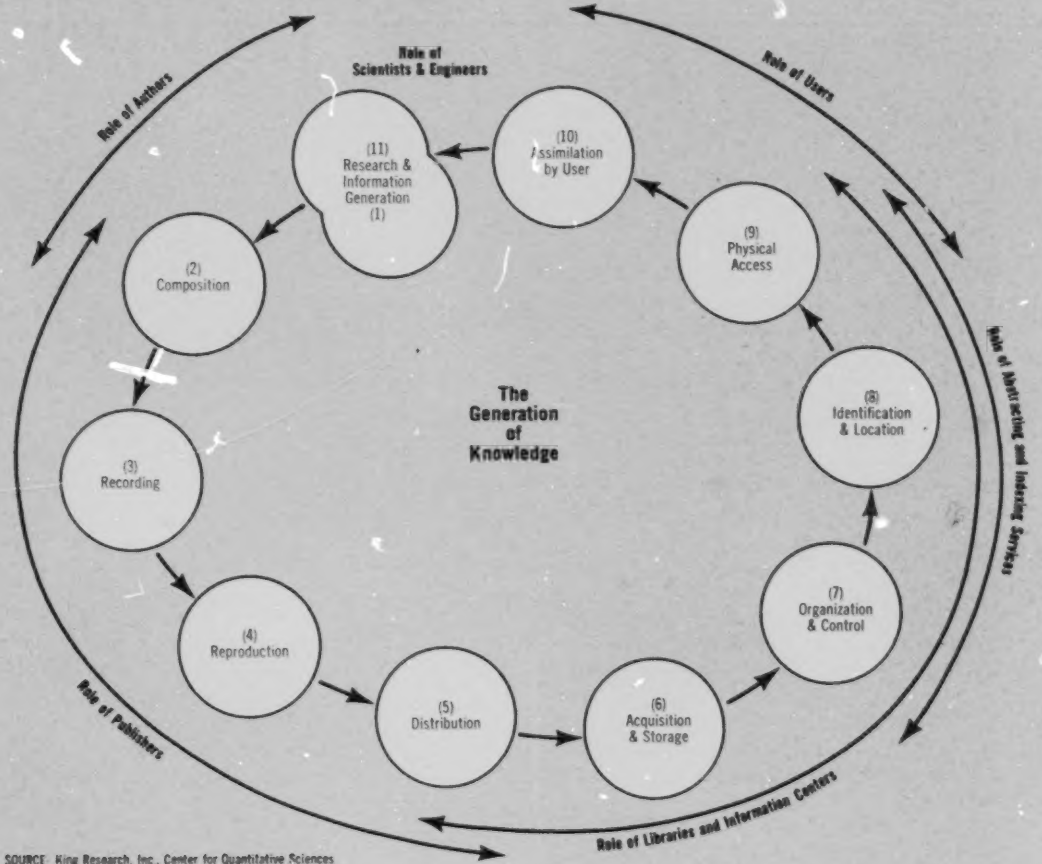
[1] The above fields of science are from "NSF Fields of Sceince Defined," *User Notes*, No. 16 (October 22, 1974). The field of Computer Sciences and Engineering was derived from the field of Mathematics as listed in Circular No. A-46, Transmittal Memorandum No. 11 (May 13, 1970) from the Bureau of the Budget (now Office of Management and Budget).

In order to gain some understanding of what has happened and anticipate what is likely to occur in the future of S&T communication, a system of statistical indicators was needed. The indicators developed as a part of this study are based on a framework or a schematic model of communication of S&T which is depicted in Figure 1. This diagram represents an information transfer spiral based on published documents, although some of the functions described in it are applicable to other forms of communication as well. The spiral includes ten functions that are essential to complete the transfer of information. These functions were chosen because they appeared to be unique in their representation of the communication processes and the statistical and economic factors related to these processes.

It is convenient to consider the spiral as beginning at *Research* which results in *Generation of Information* (1). This function is the role of scientists and engineers. Obviously, without research results to report or to communicate, there would be little need for communications media. As shown later in this report, the generation of research results and the subsequent use of research results are dependent on the number of scientists and engineers and on the resources expended on research.

Figure 1
Scientific and technical information transfer



SOURCE: King Research, Inc., Center for Quantitative Sciences

As a result of scientific research projects, manuscripts (books, articles, reports) are *composed* (2). The composition function refers to formal writing, editing and reviewing of the manuscripts. When a manuscript is in a form to be communicated it is considered to be *Recorded* (3). These two functions are the role of authors, publishers and other scientists when editing and review are performed. At this stage, in isolation, authors have very little impact on the scientific community by means of formal communication. It is not until the work has been reproduced and distributed that it has the potential for widespread influence on an audience beyond the author's circle of colleagues and fellow specialists.

The *Reproduction* (4) and *Distribution* (5) functions are usually the role of the publisher of scientific materials. However, as demonstrated later, the authors, libraries and colleagues also play an important role in reproduction and distribution. Transfer of documents through the latter three participants may be thought of as indirect reproduction and distribution which cannot take place without *Acquisition and Storage* (6). Although many individuals may acquire S&T books, articles or reports, and may store them, at least for a while, this stage of the spiral is represented by acquisition and storage by libraries and other information centers. Through their acquisition and storage policies, libraries provide a permanent archieve of scientific achievement. They also provide a guaranteed source of access to this record.

Libraries also have an important role to play in *Organization and Control* (7) functions. In addition to collecting publications, libraries and other information centers provide access to these documents through cataloging, classification, indexing and other related procedures. The major indexing and abstracting services and bibliographic services play an important role in organization and control as well. Needed publications may be *Identified and Located* (8) by a number of processes including reference to one's own subscription, library search and, recently, computerized search and retrieval systems. This function is usually accomplished by the user or an intermediary from a library or other information service. The *Physical Access* (9) function may include direct distribution of S&T articles from publishers to users as well as indirect distribution through libraries and other information centers. The final function in the spiral, that of *Assimilation by User* (10), is the least tangible. The assimilation function is the stage at which *information* (as opposed to documents) is transferred. It is at this stage that the state of the user's knowledge is altered. The functional framework is presented as a spiral because the communication process is continuous and regenerative. Through assimilation a reader may gain information that can be used in his research in such phases as conceptualization, design, research, analysis, and composition. This research may, in turn, generate new composition and recording, and so the process continues.

Each of the ten functions was carefully examined in this study concerning trends in number of items of literature processed such as books, journals, reports and so on; cost of processing the items; price of the literature; methods of processing and so on. Particular attention was paid to identifying all of the costs associated with each function. These costs sometimes were clear-cut such as in printing. However, an attempt was also made to estimate hidden costs such as in writing, reviewing and reading S&T literature. It is here that some broad assumptions were necessary to achieve a comprehensive picture of S&T communication.

STATISTICAL INDICATORS

Important indicators of S&T communication are those that correlate the growth of literature and its use to other evidence of scientific expansion in the U.S. such as number of scientists and engineers, that compare the cost of communication with general economic trends in the U.S. such as those illustrated by the Gross National Product (GNP), and that provide insight as to the strengths and weaknesses of various forms of literature and their communication functions. In this study general indicators are given for the growth over recent years of specific forms of literature including S&T books, journals, government sponsored reports as well as published dissertations, conference proceedings, and U.S. patents. The general economic outlook of each form of literature is also investigated. Furthermore, each function performed in communication of the various forms is studied in isolation to identify any aberation in trends that might

suggest a new strength or possible weakness in the form of literature or its functions.

Some background is given here for the statistical indicators with examples given for S&T books and scholarly journals since these forms of literature are traditionally so important to science and technology and since data are complete for them over the years 1960 through 1974. The other literature forms are discussed in detail along with books and journals in the sections that follow, along with figures to accompany the discussion.

Growth of the amount of scientific literature in its various forms provides a general picture of the overall health of S&T communication as well as the relative strength of each of the forms. One indicator of this growth is the total number of literature items written by scientists and engineers. Generally, all forms of literature have experienced steady growth in number of items written from 1960 to 1974 and should continue this growth through 1980. Scientific and technical books have exhibited the greatest rise from 3,379 titles in 1960 to 14,442 in 1974 (327 percent increase) and scholarly journal articles have increased from 106,000 in 1960 to 151,000 in 1974 (42 percent increase).

This growth is related to overall increase of science in the U.S. The question is whether the trend is for scientists to write more or fewer books and articles which is indicative of the strength of these forms of literature. The number of scientists per S&T book published has dropped dramatically from 343 in 1960 to 137 in 1974. By contrast the individual productiveness of scientists in writing journal articles has remained stable, but slightly decreasing over the years. The number of scientists per article written has increased from 10.9 in 1960 to 13.1 in 1974.

The number of S&T literature items written presents only a partial picture of the overall health of S&T communication. Another important element of this picture is the number of copies actually purchased since this reflects interest and usefulness of these materials The user demand for literature results from perceived quality of the literature and the price paid for the information. Thus, demand is an important indicator of the importance of the literature. The total number of copies published and the number of copies published per scientist show a substantially different picture regarding the books and journals than did the number of items written. The average number of journal subscriptions increased steadily from 3,900 domestic subscribers per journal in 1960 to 6,000 subscribers in 1974 (54 percent increase). The number of journal subscriptions (to individuals) per scientist has increased slightly over the years from 3.0 subscriptions per scientist in 1960 to 3.6 subscriptions in 1974. When institutional subscriptions are considered, the number has remained relatively constant over the years between 5 and 7 subscriptions per scientist. Scientific and technical books, on the other hand, experienced a substantial decrease in number of copies sold per book over the years from 2,400 copies per book sold in 1960 to less than 800 copies in 1974. There was a particularly large drop in the early 1960s with the trend continuing steadily downward after that time. The number of copies of books sold per scientist has remained between about 6 and 8 in the past but may decline in the future. The flat trend of copies sold per scientist of the two forms of literature suggest that there is a saturation point of the number of copies that scientists will purchase (or have purchased for them).

The average number of copies of S&T literature purchased serves as an indicator of scientific interest and usefulness. However, user demand is also dependent on the price of the literature. Price is an important indicator of S&T communication since it partially determines demand and it reflects cost and general economic stability. In current dollars, average journal subscription prices increased from $5.30 in 1960 to $20.10 in 1974 (280 percent increase). Books increased from $8.50 to $18.40 (116 percent increase). In constant dollars, the increase over this period of time was 131 percent and 28 percent for journal subscriptions to individual and institutional subscribers respectively. Books increased 31 percent in constant dollars during this time span.

Between the time S&T literature is distributed and the time it is used, substantial processing may be performed by libraries and secondary services. These institutions are responsible for the acquisition; storage; organization and control; and identification of the literature in order to provide efficient intellectual and physical access to it.

Academic library holdings experienced a 90 percent growth between 1964 and 1974. It is estimated that the number of new volumes available per scientist (including graduate students) has grown from 120 volumes in 1964

to 146 in 1974, an increase of 22 percent. Compared with a growth of 63 percent in books published and 19 percent in journals published over the same period, it appears that scientists' access to the literature by means of libraries is decreasing, were it not for the counter balancing trend of increased use of library networks. Academic library holdings increased from 189 million in 1960 to 455 million in 1974 (141 percent increase).

The total number of items processed by U.S. members and affiliates of the National Foundation of Abstracting and Indexing Services increased 145 percent between 1960 and 1974 and is projected to increase an additional 33 percent by 1980, reflecting both increased literature production and increased coverage.

Very little information is available on assimilation and use of information over time. Citation data provide some indication of quality, extent of use and relative use of the journal literature among scientific fields and international exchange. However, trends have not been observed over time so that results are not given here.

Total resource expenditures is one of the most important indicators of S&T communication. Scientific and technical communication resource expenditures have risen faster than the GNP and R&D funding. From 1960 to 1974 the GNP has grown 177 percent, R&D funding has increased 136 percent and S&T communication resource expenditures have increased substantially by an estimated 323 percent. Total communication resource expenditures were estimated to be $2.0 billion in 1960 and $8.5 billion in 1974.

The principal reasons that S&T communication resource expenditures have grown a disproportionate amount during this time is that the amount of literature written and distributed has increased substantially and the unit cost of communication has generally risen faster than inflation. These facts are clearly borne out by statistical indicators presented in the sections that follow. The growth of communication has closely paralled the increase in number of scientists. However, the growth in resource expenditures is due to other factors as well. The S&T communication resource expenditure in constant dollars per scientist has increased from about $2000 in 1960 to $3000 in 1974 and is expected to remain about the same until 1980. This 50 percent increase over time is attributable to a large increase in scientists' salaries and other costs of producing and processing S&T literature. A substantial proportion of the resource expenditures is due to scientists' time devoted to writing, editing, reviewing, searching, and reading the S&T literature. Their salaries have increased at a rate greater than inflation, with their median salaries in constant dollars increasing from $10,700 in 1960 to $13,300 in 1974. In addition, costs of reproducing and processing S&T literature have also increased at a rate faster than inflation. This is partially due to the fact that salaries related to such things as publishing, printing, abstracting and indexing, and libraries have all increased at a rate greater than inflation. Another portion of the remaining contributions to expenditures is due to the increased number of S&T books and reports produced per scientist. These indicators are presented in the third section. It is pointed out that some technological advances such as computerized photocomposition have eased the cost squeeze to some degree. In the future, it is anticipated that computerized searching, microform publishing, library networking and other innovations are also likely to have some positive impact on the economics of S&T communication.

The costs attributed to S&T journals rose from $1.1 billion in 1960 to $5.6 billion in 1974 (330 percent increase) while the costs associated with S&T books increased from $600 million to $2.1 billion during this time (over 250 percent increase). Reports and other forms of literature accounted for the remainder of the expenditures. Most of the costs are contributed by scientists' labor in writing and using S&T literature. The writing (composition and recording) was $300 million in 1960 and increased to $1.8 billion in 1974 (nearly 500 percent increase). These costs are based on estimates of the average amount of time spent on such activities as writing, editing, reviewing, and typing manuscripts. The total costs are found by multiplying the labor costs by the number of manuscripts written and published. Thus, growth in costs reflect both increases in salaries as well as number of items. Similarly, costs for assimilation rose from $1.0 billion in 1960 to $3.6 billion in 1974 (260 percent increase). Reproduction and distribution costs rose from $150 million in 1960 to $930 million in 1974, an increase of 520 percent. Acquisition and storage costs increased from $37 million in 1960 to $180 million in 1974, reflecting a growth of 390 percent. The increase for

organization and control costs was similar at 370 percent, ranging from $58 million in 1960 to $270 million in 1974. Costs associated with identification and access rose from $400 million in 1960 to $1.7 billion in 1974, an increase of 320 percent.

The second chapter discusses the resource expenditures in detail with the total distributed by participants (scientist, publisher, library and user), form of literature (journals, books, reports and other forms), and communication function. Chapter 3 gives detailed data for the growth of the various forms of literature. The next chapter deals with trends observed in libraries and secondary products and services. The final chapter provides information and trends concerning the use of S&T information. Particular attention is given in the last chapter to trends in citation use and how users identify and gain physical access to journal articles. Most of the trends are depicted in graphic form. All data in the figures are also given in the Appendix[1].

[1] Table numbers correspond to the figure numbers for convenience. For the figures with no numbers plotted there will be no corresponding tables.

Chapter 2

Growth of Scientific and Technical Communication Resource Expenditures

Chapter 2

Growth of Scientific and Technical Communication Resource Expenditures

Total resource expenditures is one of the most important indicators of scientific and technical (S&T) communication. An attempt has been made in deriving statistical indicators[1] to identify and analyze all the components of resource expenditures of S&T communication.

The term "resource expenditure" is used because the total expenditure is expressed in terms of both funds as well as manpower. It will be shown that the funds expended in communication of scientific and technical information (STI) are increasing rapidly, at a pace greater than both the Nation's Gross National Product (GNP) and also the funds expended for research and development (R&D). This growth is highly correlated with increases in scientific manpower, and communication activities should continue to grow as the scientific manpower expands. In this chapter the total S&T communication resources expended are subdivided by mode of communication (books, journals, reports, and so on), and by principal participants (scientists as authors, publishers, libraries, and secondary services, and scientists as users). Thus, the various communication modes and principal participants can be compared as to their relative contribution to total resources expended.

HIGHLIGHTS

- The total resources expended in S&T communication in the U.S. are estimated at $9.4 billion in 1975. This figure includes the costs incurred by authors, publishers, libraries and secondary services, and users in the production and use of S&T books, journals, reports, and other publications.

- The total resources expended in S&T communication are growing at a faster rate than the GNP. The GNP has grown 177 percent from 1960 to 1974, whereas total resources expended have increased from $2.0 to $8.5 billion, or 320 percent. The future trend in communication resource expenditures, however, appears to reverse and may begin downward.

- The growth of resource expenditures of S&T communication is particularly pronounced when compared to R&D funding levels. The ratio of S&T communication resource expenditures to R&D funding levels was 0.149 in 1960 and has swelled to 0.266 in 1974. If this trend continues, the proportion of STI resources allocated from R&D funding will complete more and more heavily with other R&D activities. R&D funding levels are expected to increase in the near future so that these pressures may not be too critical, but bear observing.

- The number of scientists and engineers increased at an average annual rate of 3.8 percent from 1960 to 1975 and is expected to begin levelling off to an average annual rate of increase of 2.7 percent. This should mean that the amount of STI services and products will also level off accordingly since there will be relatively fewer producers and users of them. Perhaps, more importantly, since the demand for scientists in the labor market has gone down, their salaries have also levelled off. This trend could result in relatively lower S&T communication resource expenditures.

[1] These data are presented with some caveats which are discussed here and, more thoroughly, in the companion document: *Volume II: A Research Report.*

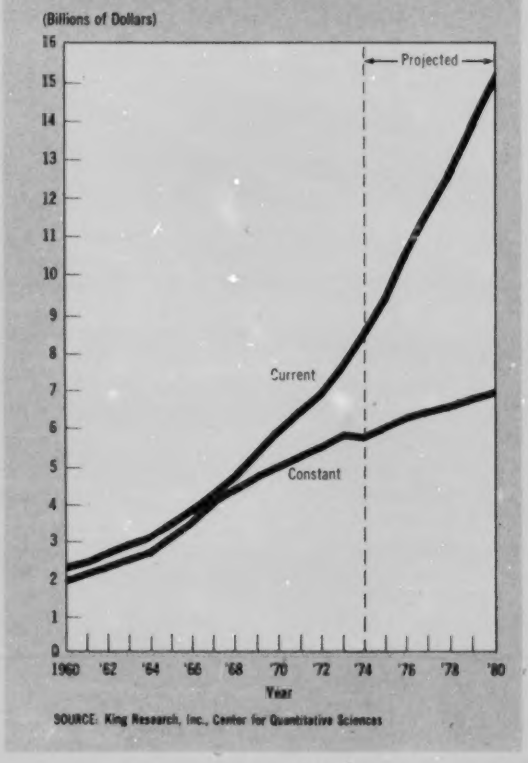
- Scientific and technical communication resource expenditures in constant dollars per scientist have increased from about $2000 in 1960 to $3000 in 1974 and are expected to remain about the same until 1980.
- Scientific and technical journals, when scientists' time is taken into account, made the greatest contribution to total S&T communication resource expenditures at about 63 percent of the total. Books added another 28 percent in 1960 (25 percent in 1974). About 60-70 percent of the total expenditures is attributable to individual scientists in writing, editing, reviewing, and reading S&T literature. Libraries and secondary services contribute about one-fourth of the total and publishers add less than ten percent to the total costs. Since such a large expenditure comes from scientists and their efforts, perhaps more careful efforts should be made to evaluate and support their S&T communication activities.

DISCUSSION

The total resources expended on S&T communication are computed by summing all resources and costs associated with preparing, publishing, distributing and using the range of S&T literature. This encompasses the efforts of all participants in the system, including scientists as both authors and users, publishers, libraries and secondary services. The total communication resource expenditures shown in Figure 2 have increased rapidly in both current and constant dollars since 1960. Current dollar expenditures have increased from a figure just over $2 billion to $9.4 billion in 1975. In constant dollars, the average rate of increase between 1960 and 1975 was 6.6 percent; and continued annual increases over 3 percent are forecast through 1980.

The resources expended in the communication of STI are considerable. They are, however, only a portion of the total resources expended by the entire U.S. information sector. Porat**[8]**, based on previous work of Machlup**[6]**, for example, defines information activity to represent a primary sector of the economy, which is made up of industries which sell information goods and services, and two planning sectors, private and public.

Figure 2
Total S&T communication resource expenditures (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

According to Porat, activities of these three components of the information economy in 1967 together accounted for over $360 billion or over 45 percent of the GNP. The primary information sector alone represented over $160 billion in information value added, or 20 percent of the GNP. The expenditures presented in this monograph reflect the portion of total expenditures which is related to S&T communication, and to the transfer of information primarily by means of the published literature.

The general health of S&T communication can be assessed by comparing resource expenditures to the GNP and to R&D funding. The GNP serves as a general indicator of economic condition in the U.S. Thus, it is used as a base against which to compare the resources expended in S&T communication. Figure 3 shows the GNP from 1960 to 1980 in current dollars. Constant dollars are computed by

using the GNP implicit price deflator, with 1967 as the base year. The value of the GNP in constant dollars has grown an average of 3.3 percent annually between 1960 and 1975, and is expected to continue increasing at an average of 4.2 percent annaully to 1980.

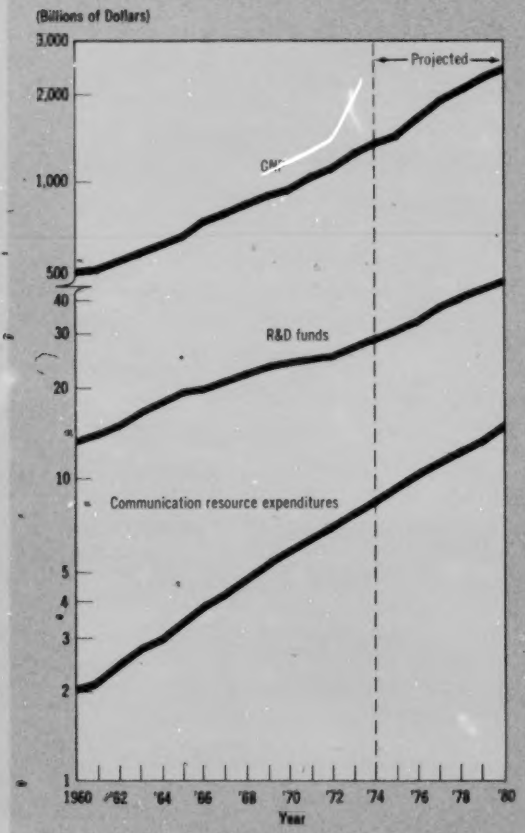
Estimated total S&T communication resource expenditure is presented along with GNP and R&D funding in Figure 3 in current dollars. The S&T communication resource expenditures have clearly risen faster than the GNP and R&D funding. From 1960 to 1974 the GNP has grown 177 percent, R&D funding has increased 136 percent and S&T communication resource expendtiures have increased much more by an estimated 323 percent. Trends in the relative growth of communication resource expenditures to GNP and R&D funding are given below.

The ratio of S&T communication resource expenditures to GNP is given in Figure 4.

In 1960, S&T communication resource expenditures accounted for 0.4 percent of the GNP. The percentage increased steadily over the years, reaching about 0.6 percent in the early 1970's. The forecast is for a slight continued increase and then a decline back to around 0.6 percent by 1980.

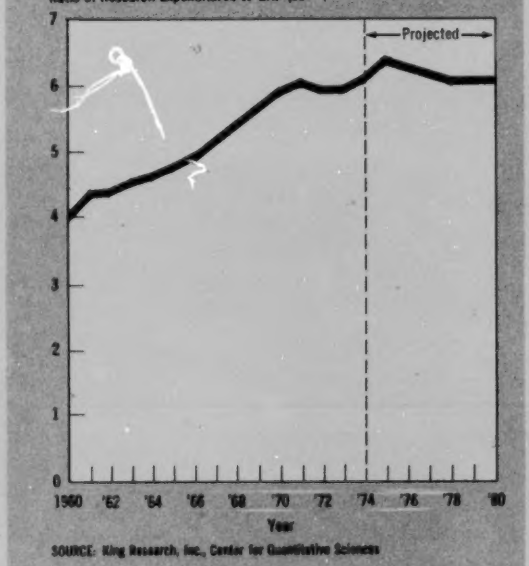
The second comparison is that of S&T communication resource expenditures and R&D funding levels. Though the exact relationship is unknown, much of the resources expended in S&T communication (particularly in the generation and use of information) come from R&D funds. For this reason, these two categories might be expected to grow at the same rate. Figure 5 shows the ratio of the two values.

Figure 3
Total S&T communication resource expenditures, gross national product, and research and development funds, in current dollars (1960-1980)



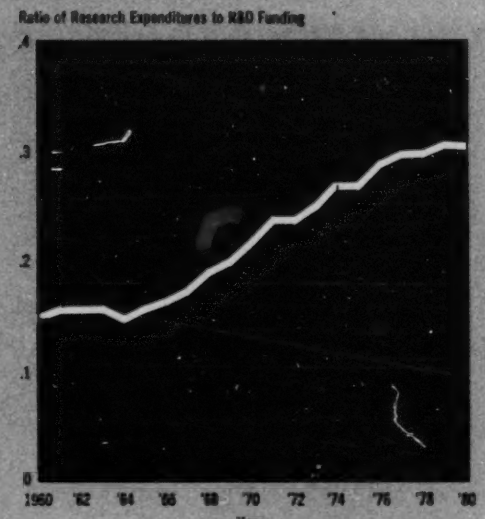
SOURCE: Economic Report of the President, February 1975 GNP, (GNP) 1960-1974
National Planning Association (GNP) 1975-1980
King Research, Inc., Center for Quantitative Sciences (ST) Communication 1960-1980, R&D Funds 1975-1980
National Science Foundation, National Patterns of R&D Resources, 1953-1975 (NSF 75-307) (R&D Funds)

Figure 4
Ratio of S&T communication resource expenditures to GNP (1960-1980)



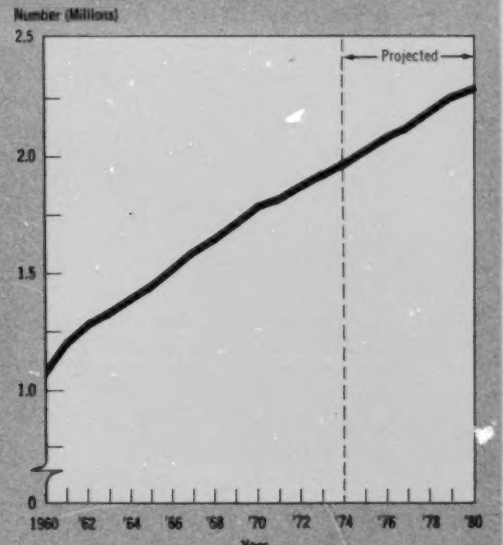
SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 5
Ratio of S&T communication resource expenditures to research and development funding (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 6
Estimated number of scientists and engineers (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

The ratio of communication to R&D expenditures remained constant at about 0.16 from 1960 to 1964 but has risen steadily since 1964 and will continue to do so through 1980. As indicated previously, R&D funds increased 136 percent between 1960 and 1974, and are forecast to increase an additional 51 percent between 1975 and 1980. For the same periods, communication resource expenditure increases are 323 and 77 percent, respectively.

The dramatic rise in communication resource expenditures suggests the increasingly important role which STI plays in our society and in R&D. This reflects a healthy increase in the volume of S&T communication. On the other hand, there could be problems if the cost of communication rises faster than the cost of other scientific activities that share common R&D budgets.

As stated above, an important consideration related to the growth of S&T communication expenditures is the increase in the number of scientists and engineers. These data are presented in Figure 6. There were about 1.2 million scientists and engineers in 1960 and about 2.0 million in 1975.[2] The average annual growth rate over this period was 3.8 percent.

The number of scientists is divided into the estimated total communication resource expenditures to determine the average expenditure per scientist or engineer. This is shown in Figure 7.

The resources expended per scientist equalled about $1700 in 1960 and $4300 in 1974. In constant dollars, average expenditures reflect an increase from about $2000 to $3000, or 50 percent. Projections suggest that the average constant dollar expenditure will level off over the next 5 years (1975-1980), remaining at around $3000.

As mentioned previously, one of the major reasons average S&T communication resource expenditures have risen is that much of the total resource expenditure is a function of scientists' salaries, and these salaries increased more rapidly than inflation up to 1973.

[2] The total number of scientists and engineers presented here includes social scientists.

This trend is expected to level off through 1980. The S&T communication resource expenditure per scientist is shown in Figure 8 as a ratio of median scientists' salaries.

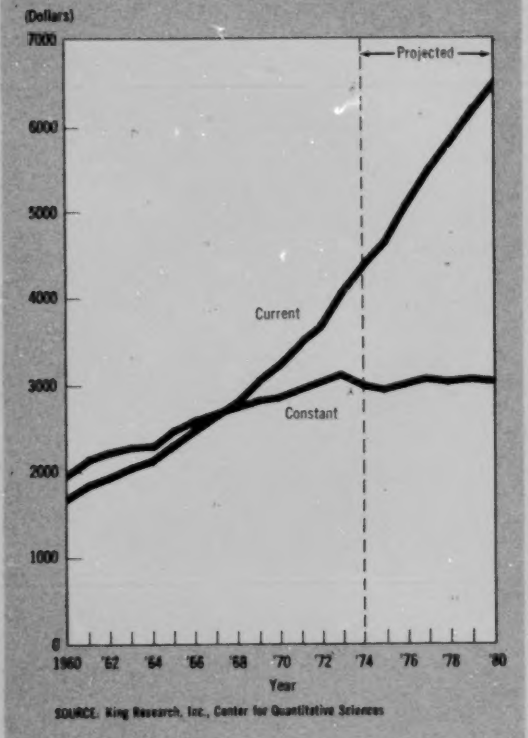
As indicated, there is little change in this relationship over the years after 1973. The elements of S&T communication resource expenditures attributable to scientists and the role which scientists' salaries play in determining these expenditures are considered in more detail in Chapter 5.

An important basis for understanding S&T communication resource expenditures is the components which make up these expenditures and their respective growth. Much of the remainder of this monograph is devoted to development of cost factors which were included in the total, covering in detail each component. The remaining data in this section summarize these results, presenting total communication resource expenditures, by medium, by participant, and by participant within each medium. For each presentation, both current and constant dollar figures are given.

Distribution of the total communication resource expenditures for journals, books, reports and other forms of literature is shown in Figures 9 and 10 for current and constant dollars, respectively.

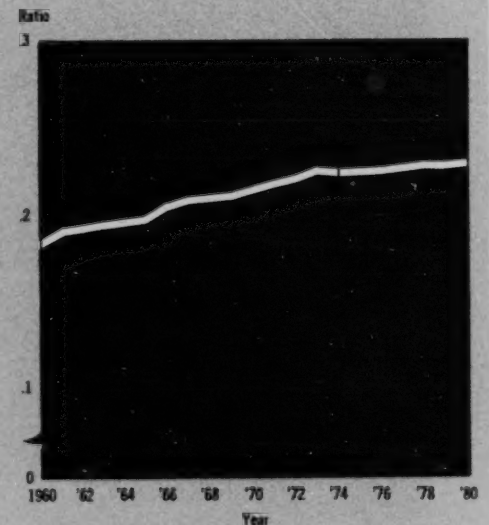
The journal figures shown are based on all U.S. S&T journals, including both scholarly journals as well as trade, technical and other types of S&T periodicals. There were about 8,000 such journals in 1974. Books covered in the cost figures were hard-cover S&T publications which included over 14,000 titles in 1974. Report cost figures are based on a subset of the total number of reports generated which includes only those titles released through the Government Printing Office or the National Technical Information Service. Other literature includes doctoral dissertations, U.S. patents, and conference proceedings.

Figure 7
S&T communication resource expenditure per scientist or engineer in current and constant dollars: (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

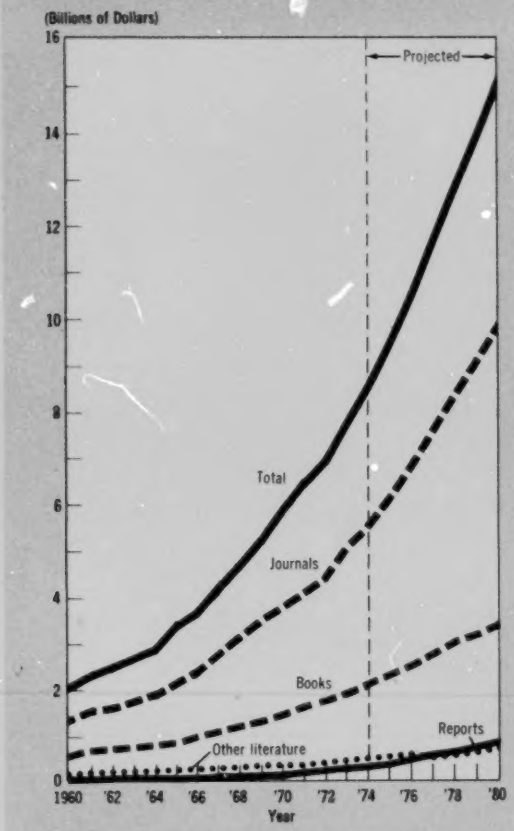
Figure 8
Ratio of S&T communication resource expenditure per scientist to median scientists' salaries (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 9

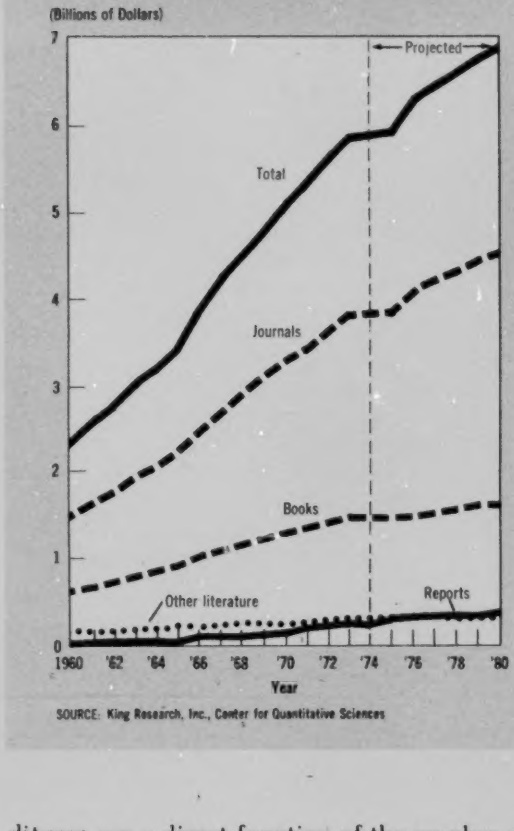
Total S&T communication resource expenditures by medium in current dollars (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 10

Total S&T communication resource expenditures by medium in constant dollars (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

The total expenditures associated with journals are much higher than with the other forms of literature. The journal expenditures were about $1.3 billion in 1960 and rose steadily to $5.6 billion in 1974. They are expected to continue increasing up to $9.9 billion in 1980. The proportion of total expenditures associated with journals was 63 percent in 1960 and is expected to continue at that level up to 1980. The total expenditures attributable to S&T books was $600 million in 1960 and $2.1 billion in 1974 with an expected increase to $3.5 billion in 1980. Expenditures associated with books comprised 28 percent of the total in 1960 and are expected to go steadily down to about 25 percent in 1980. Expenditures are a direct function of the number of S&T materials (book titles, journal articles, reports, dissertations, and so on); and the number of materials are, in turn, closely correlated with the number of scientists. Development of these relationships form the basis for statistical indicators presented in the next chapter.

The contribution to overall resource expenditures attributable to the principal S&T communication participants (scientists as authors of the literature, publishers, libraries and secondary services, and scientists as users of the literature) is given in Figure 11 and Figure 12 for current and constant dollars, respectively. Resources are determined for scientists largely by their time devoted to writing, editing and reviewing literature as well as to using S&T literature. Publishers contribute to total expenditures by the costs they incur in reproducing and distributing

Figure 11
Total S&T communication resource expenditures by participants in current dollars (1960-1980)

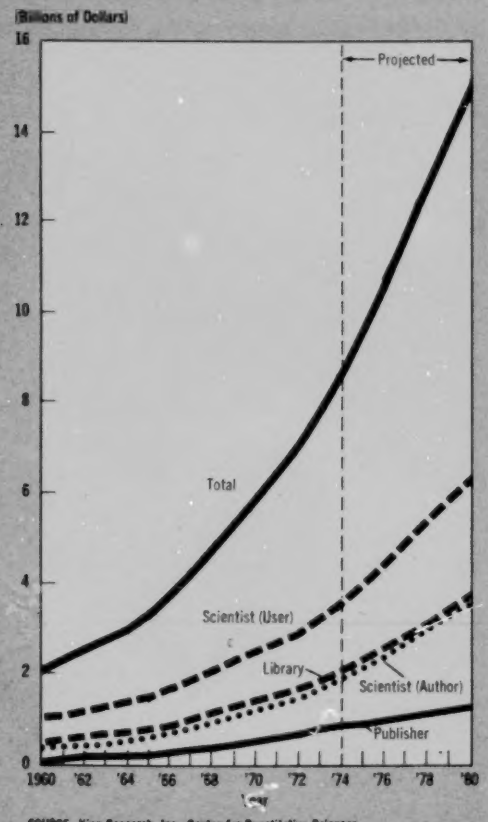
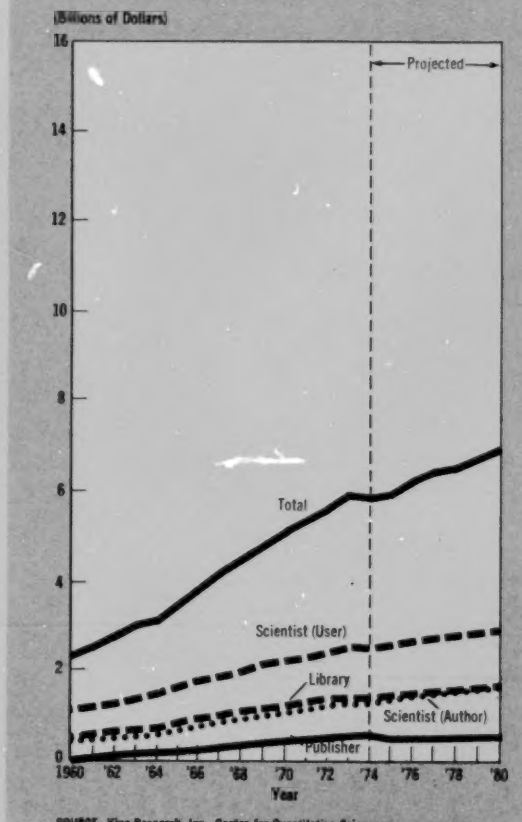


Figure 12
Total S&T communication resource expenditures by participants in constant dollars (1960-1980)



literature. Libraries and secondary services incur expenses in acquiring and storing literature, providing management and organization of the literature (cataloging, abstracting and indexing) and identifying, locating and providing physical access to the literature.

The largest contribution to total resource expenditures is by scientists who use the literature. They contributed about one-half of the total resource expenditures in 1960, although the contribution decreases to about 40 percent in 1980. The decrease is attributable to the dampening in number of scientists and to the levelling off of their salaries. Library and secondary services contribute about one-fourth of the expenditures over the entire span of time. Publishers contribute less than 10 percent over the period 1960 to 1980, and scientists, as authors of the literature, contribute about 17 percent in 1960 and this proportion is expected to increase to 23 percent in 1980.

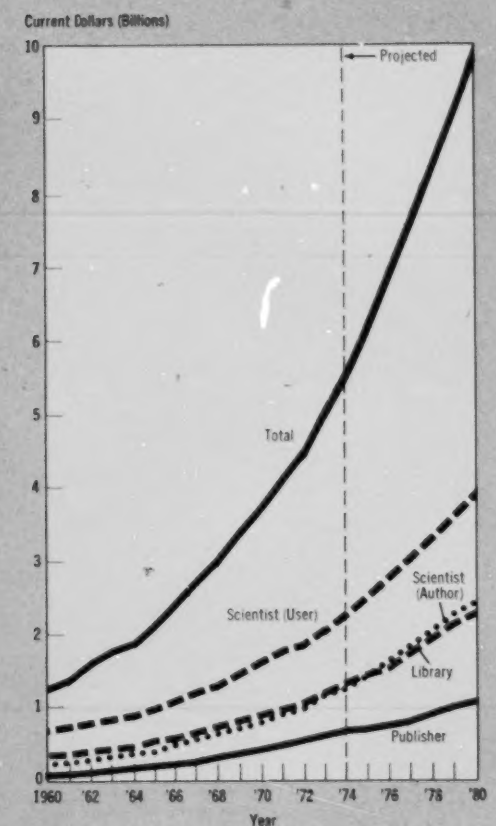
Data are shown below for the participants' contributions to each of the major literature forms (books, journals, and reports) and to the combined other literature. Journal communication costs are shown in Figure 13. Journals account for nearly two-thirds of total communication costs and they also account for a large percentage of the costs associated with each participant. Publication costs are higher

for journals than for the other media, and their percentage contribution to the total rose steadily over the 1960 to 1974 period. Library-related costs for journals (exclusive of subscription prices) have also been rising, but at a slower rate.

Most striking in the journal costs are the rates of growth observed in the 1960 to 1974 period; 520, 718, 290, and 249 percent respectively for scientists, publishers, libraries and users. These rates are equivalent to average annual increases of 13.9, 16.2, 10.2, and 9.3 percent, respectively.

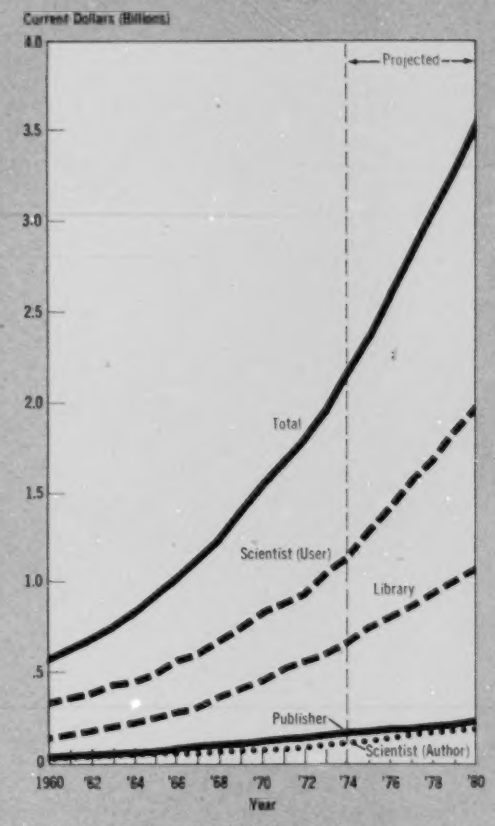
Figure 14 shows the resource expenditures of book communication. The total expenditures attributable to S&T books was $600 million in 1960 and $2.1 billion in 1974 with an expected increase to $3.5 billion in 1980. More than half of these are the user costs of reading, with libraries accounting for about another third of the total. Publication costs decreased slightly as a percentage of the total over the 1960 to 1974 period and are projected to continue declining to 1980. This reflects a relative decrease in the significance of books versus other forms of S&T literature. At the same time, the cost of authorship is expected to rise, so that it will be nearly as large as publication costs by 1980. As will be shown in Section 3 with each of the literature forms, the

Figure 13
Total S&T journal communication resource expenditures by participants: (1960-1980)



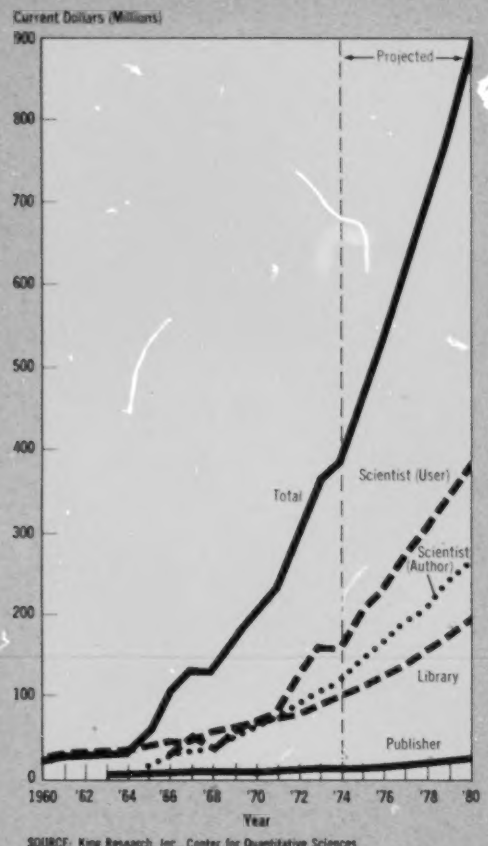
SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 14
Total S&T book communication resource expenditures by participants (1960-1980)



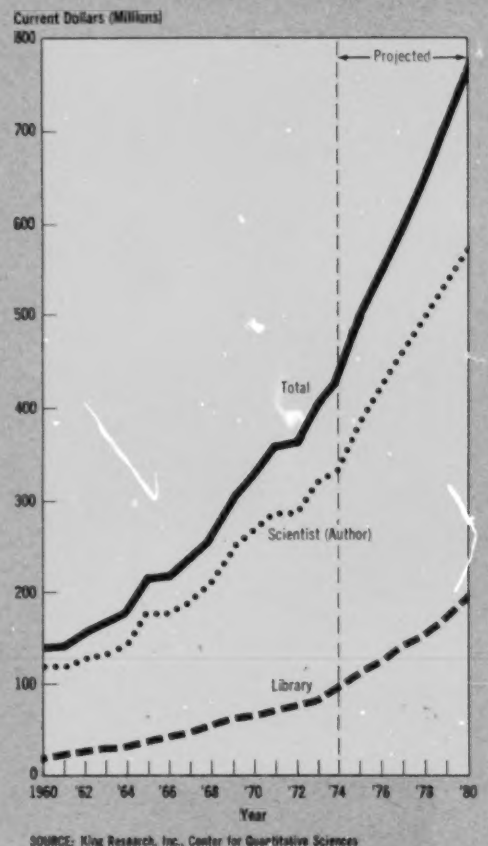
SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 15
Total S&T report communication resource expenditures by participants (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 16
Total S&T other media communication resource expenditures by participants (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

costs anticipated to show the greatest increases over the 1975 to 1980 period are those which are directly related to scientists' salaries as mentioned earlier though. The growth rate should be leveling off over this time period.

Report expenditures are shown in Figure 15. These data are not as well defined and should be treated accordingly. The report expenditures were about $22 million in 1960 and $390 million in 1974. They are expected to continue increasing up to $880 million in 1980. In 1970 the author, library and user each accounted for about one-third of the total costs, with publishing representing only two percent. The most significant change forecast in these breakdowns is expected to be a substantial increase in user expenditures, so that these will make up about 44 percent of the total by 1980. Total report expenditures are projected to rise 86 percent between 1975 and 1980, the largest increase of the four literature forms. This increase is apparently due to the rapid growth in the volume of the literature combined with the great proportion of user-related costs which depend directly on scientists' salaries. Note that these figures are conservative estimates of the expenditures associated with reports due to availability of government distribution data only.

Figure 16 illustrates the expenditures of

communication by means of "other" media, primarily patents and dissertations. These figures also include some expenditures for library handling of audiovisuals, pamphlets, and the like. The total expenditures attributable to "other" media was $140 million in 1960 and $430 million in 1974. They are expected to continue increasing up to $770 million in 1980. The primary expenditure associated with "other" media is for the composition and recording, and this is about twice as large as the cost of composition and recording for reports.

Chapter 3

Growth of Scientific and Technical Literature in the United States

Chapter 3

Growth of Scientific and Technical Literature in the United States

The heart of scientific and technical (S&T) communication is the formal literature. This section deals with the growth of S&T books, journals, reports, and other literature such as conference proceedings, patents and doctoral dissertations. Statistical indicators of trends in the growth of each form of literature are presented in number of items prepared; number of copies reproduced and distributed; cost of composition, recording, reproduction, and distribution; and price of the literature. In this section it is shown that book productivity has increased substantially but that it is unlikely to continue because of economic constraints. Other forms of S&T literature demonstrate a much healthier growth than books. Each form of literature is discussed in detail.

HIGHLIGHTS

- The number of S&T book titles has shot up from about 3,000 titles in 1960 to about 14,000 in 1974. Individual author productiveness during this time has increased from one book published for every 343 scientists in 1960 to one book for every 137 scientists in 1974. However, there are some very ominous signs in the S&T book publishing industry. The number of copies sold per book title has dropped more than half from 1960 to 1974 and, even though prices have risen sharply, the revenue per book title has also plummeted. The number of copies sold per scientist has remained almost constant over the years at approximately 6 to 8 copies even though the number of titles has increased dramatically and the average number of copies sold has dropped. Thus, number of book copies sold per scientist may be a variable of some stability in the industry. In the future, one or more of the following actions are likely to be taken by publishers: increased prices, more careful screening of book manuscripts, or implementation of processes which reduce costs (particularly prerun costs). Otherwise the S&T book publishing industry may be in serious economic difficulty.

- The journal publishing picture is much brighter than that observed for S&T books. The number of journals published has not increased dramatically since 1960. A steady growth of 2 percent per year reflects number of scientists almost perfectly (correlation coefficient r=0.99), although individual author productiveness has declined from one scholarly article published for 10.9 scientists in 1960 to one article per 13.1 scientists in 1974. The productivity varies substantially among the fields of science with Life Sciences having the most productive individuals. Engineering the least productive. The number of subscriptions has increased on the average, although some individual journals have experienced a depressing decline. The prices (whether considered by total subscription, by article, or by kiloword page) have increased somewhat even in constant dollars. Trends in all these areas are expected to continue through 1980 at slightly diminished rates of growth. While journals experiences an average annual growth rate of 2 percent between 1960 and 1974, the growth rate for journal articles was 2.6 percent. This slightly higher growth rate for articles is reflected

in the number of articles per journal which was estimated to be 71 in 1960 and 77 in 1974.

- The number of articles distributed by subscription to institutions or individuals has increased when considered as an average over number of scientists. For example, the number of articles distributed to individuals has increased from about 210 in 1960 to about 280 in 1974. Similarly, the number per scientist distributed to institutions has increased from 140 in 1960 to about 180 in 1974. In both instances, the distribution is expected to be level up to 1980.

- Report literature, as measured by sales at the National Technical Information Service (NTIS) and Government Printing Office (GPO), has also experienced rapid growth. The total copies sold at NTIS has increased from 784,000 in 1966 to 2,356,000 in 1974. Much of the growth is attributable to increased coverage of the government report literature. Furthermore, much of the growth has been through microform rather than paper copy. The microform sales per report have increased 106 percent during this period, while the paper sales per report have decreased 58 percent. The average number of copies sold at GPO has increased 36 percent. In both agencies, prices of reports have increased substantially and they are expected to continue this increase. The increase in price of paper copy and other considerations are likely to continue altering sales patterns toward more microform copies. This may have a great impact on the microform industry and have a secondary effect on other S&T media.

- The number of conference proceedings, U.S. patents and doctoral dissertations have all increased substantially over the years. Published conference proceedings have increased 40 percent from 1965 to 1971. The number of U.S. patents issued has increased about 60 percent from 1960 to 1974. The number of dissertations published has more than tripled in this same time period. The growth pattern of all these forms of literature is forecast to continue at a slightly dampened rate.

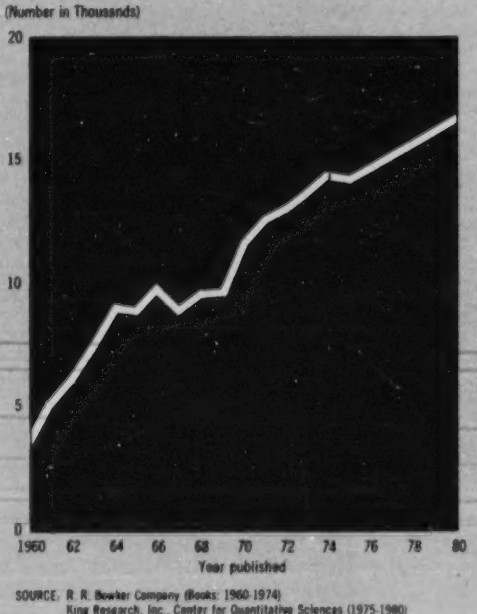
DISCUSSION

Growth of Scientific and Technical Book Literature in the United States

The S&T book literature, although showing healthy increases in number of books published, does have some ominous indicators that are discussed later. As shown in Figure 17, the number of S&T book titles published in the U.S. has increased substantially. The growth was particularly pronounced in the early 1960's. From 1960 to 1964, the increase was 162 percent from 3,379 books to 8,871 books. Over the next 5 years, the growth was only 8 percent. However, in 1970, the number of books published continued again to grow rapidly up to 14,442 in 1974. Thus, the total increase from 1960 to 1974 was a substantial 327 percent, but with some lulls and spurts. The forecast over the next 6 years is for continued growth but not as substantial as during the two spurts represented in the early 1960's and 1970's.

As one might expect, the relationship of the number of books published and the number of scientists is very high. This relationship is

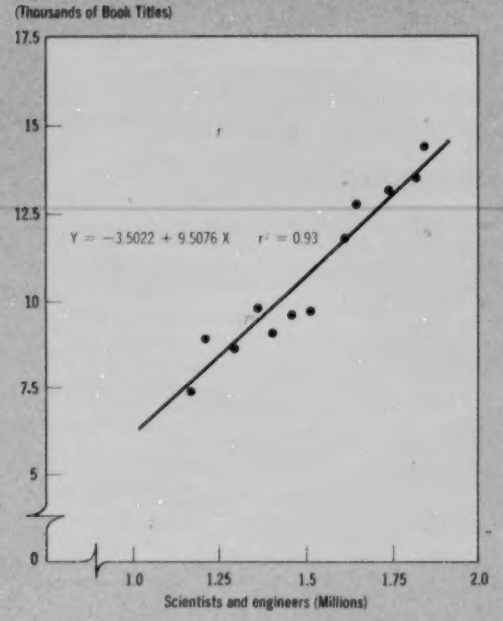
Figure 17
Total S&T book titles published (1960-1980)



SOURCE: R. R. Bowker Company (Books: 1960-1974)
King Research, Inc., Center for Quantitative Sciences (1975-1980)

shown in Figure 18. The values used for the number of scientists in the relationship shown are number of scientists lagged 3 years prior to the number of titles published. For example, scientists in 1968 perform work and write books that are published in 1971 since it takes roughly 3 years to publish a book after it is begun. Thus, 1968 scientists are related to 1971 books in the figure. The high correlation of this relationship is demonstrated by values of the correlation coefficient, r=0.96.[1] Similar analyses were used for the number of scientists having doctoral degrees (r^2=0.82) and for Federal funding obligations for research and development (R&D) (r^2=0.79)[2].

Figure 18
Total S&T book titles published as a function of number scientists and engineers



SOURCE: King Research, Inc., Center for Quantitative Sciences

[1] Thus, r^2=0.93 which means that about 93 percent of the variation occurring among the number of book titles published over the years can be explained by the number of scientists. r^2 values are given for comparative purposes even though the small number of observations for each computation make them questionable.

[2] These variables were also included along with others in a stepwise multiple regression model but were dropped due to high colinearity among the independent variables. This comment holds true for nearly all regression analysis mentioned in the remainder of this report.

Forecast of the number of scientists is used in the regression equation to estimate number of S&T books published from 1975 to 1980 as given in Figure 17. Based on this forecast technique, the number of titles should increase at an average annual rate of 3.4 percent from 1975 to 1980.

Data on book publishing were not available for the nine fields of science defined by the National Science Foundation. However, data are available for 6 science classifications.[3] In each science classification, the number of book titles was correlated with number of scientists, number of scientists with doctoral degrees and Federal R&D obligations in the corresponding NSF field of science. These values were used to forecast the number of book titles published which are shown in Figure 19 for the 6 science classifications. Sociology and Economics not only had the largest number of books published in 1974 (6,640) but also showed a remarkable 780 percent increase in books published from 1960 to 1974. Medicine also had a large increase in number of books published from 520 in 1960 to 2,281 in 1974 which represents a 339 percent rise.

The dramatic increase in number of books published has been accompanied by an equally startling decrease in estimated number of copies sold per book title published.[4] This decrease is shown in Figure 20 below.
The number of copies sold per title has plummeted from 2,394 in 1960 to 789 in 1974. It appears that there is a saturation point of the number of copies that scientists will purchase (or have purchased for them) which is depicted by the estimated number of copies sold per scientist in Figure 21. The number of copies sold per scientist has remained relatively constant over the years, ranging from a little under 6 to 8 copies. The trend in number of book copies sold and, hence, revenue per title is decreasing dramatically.

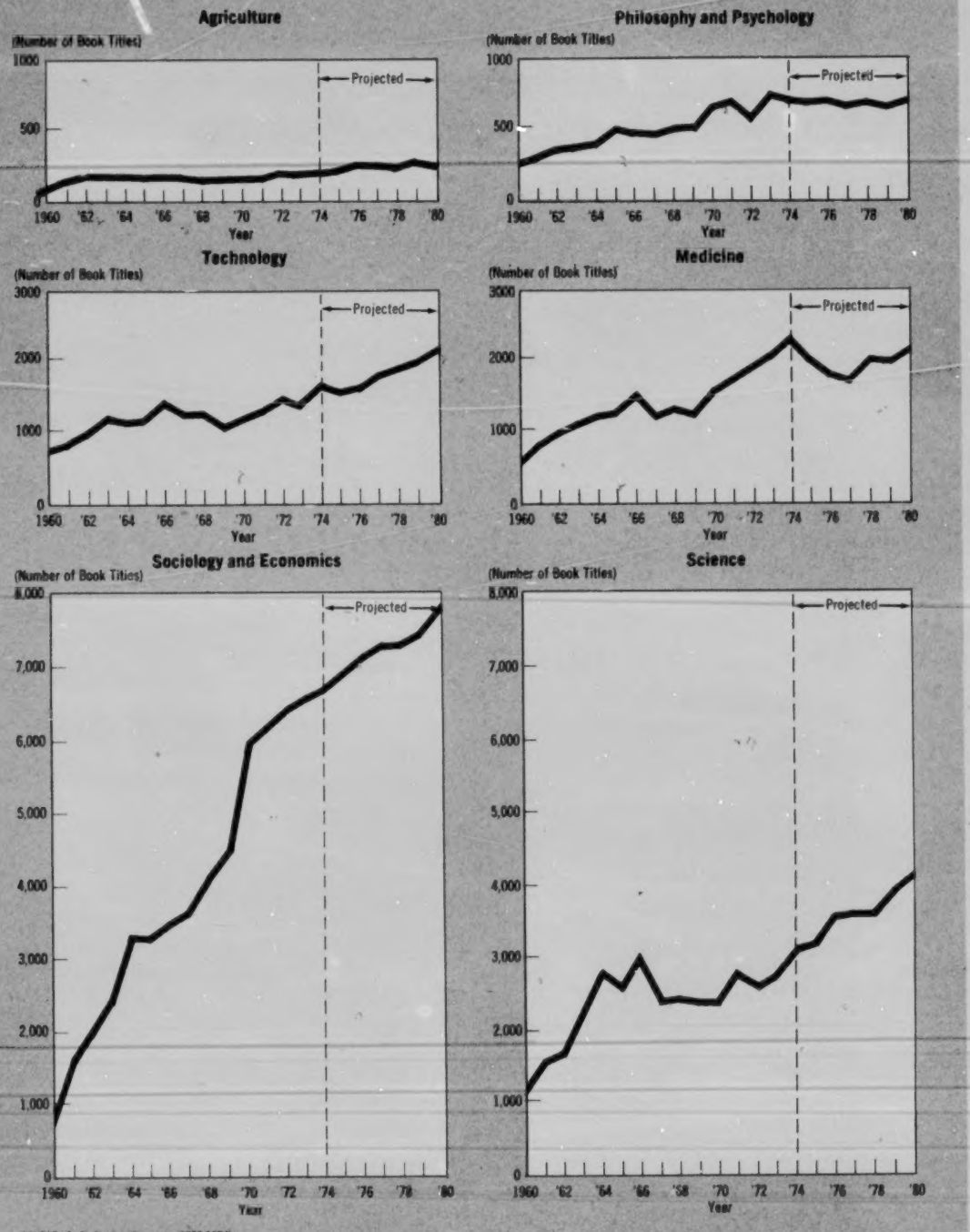
Financial success in book publishing is particularly dependent on volume of sales since initial fixed cost is quite high and must be spread out over this volume of sales. Thus, it would appear that the substantial decrease

[3] Definitions for these science classifications are given in Volume II: A Research Report.

[4] Note that a detailed analysis has not been made concerning the impact paperback books have had on the S&T book market.

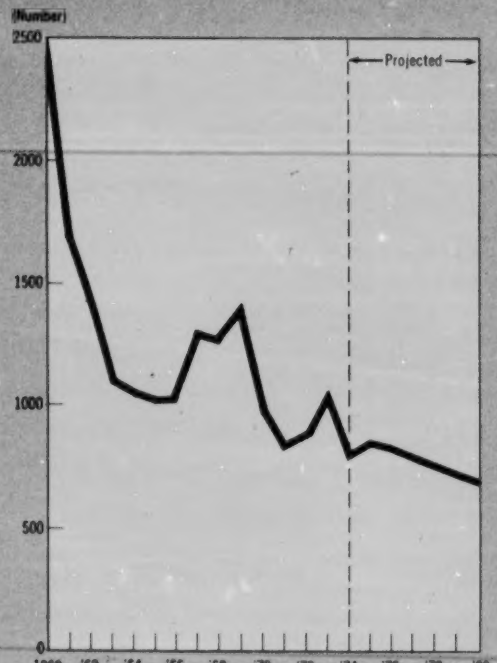
Figure 19

S&T book titles published by six classifications (1960-1980)



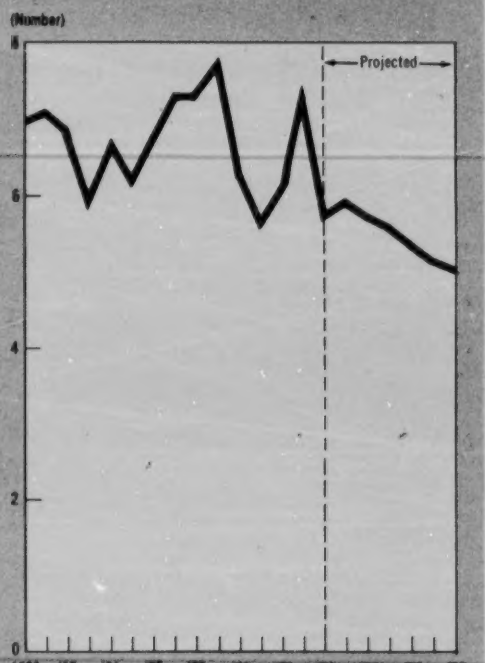
SOURCE: R. R. Bowker Company (1960-1974)
King Research, Inc., Center for Quantitative Sciences (1975-1980)

Figure 20
Average number of copies sold per book title (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 21
Average number of book copies sold per scientist or engineer (1960-1980)



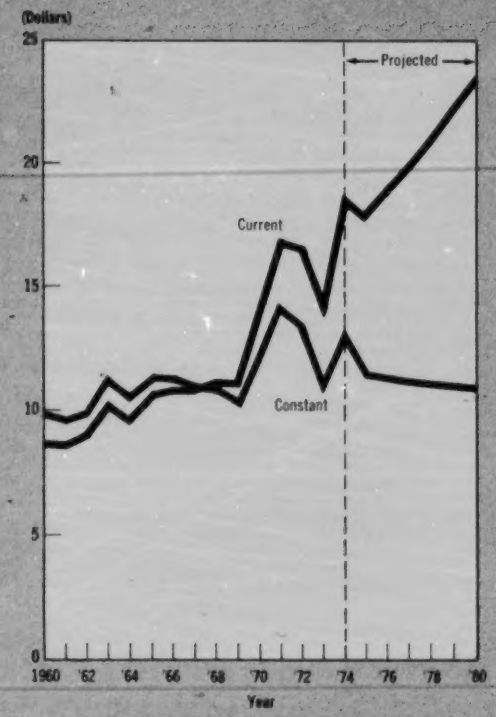
SOURCE: King Research, Inc., Center for Quantitative Sciences

in book copies sold per title must have a devastating impact on publishers unless this decrease is accompanied by corresponding increases in price. The average price per book is given in current and constant dollars in Figure 22. The average price in current dollars increased from $8.50 in 1960 to $18.40 in 1974. However, in constant dollars the increases have not been quite so dramatic. The overall increase in constant dollars from 1960 to 1974 was 31 percent.

Total S&T book receipts show a steady increase from 1960 to 1974 and the receipts are forecast to continue this trend. However, receipts per book title, which result from the reduced sales per book and increased price, show a sharp decline (in constant dollars) after 1969. The receipts per title are given in current and constant dollars in Figure 23. Since 1962, the receipts per book title in constant dollars are in the $10,000 to $15,000 range and have a fairly flat trend over the years. If the cost of producing books does not also remain constant over the years, say, due to reduced number of pages, use of paperback covers or some other factor, the book publishers must surely be hurt in terms of reduced profits or even losses.

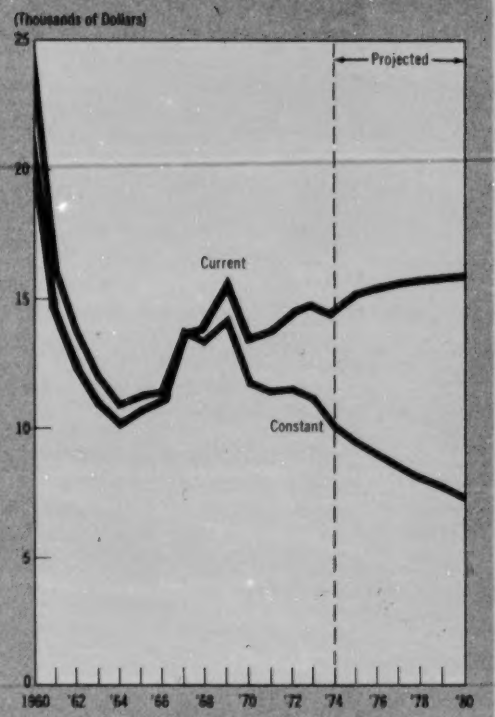
If the number of books published per scientist remains too high, one of several events may occur in the future. Fewer books may be accepted by the publishers, action may be taken to reduce costs (such as publishing by paperback or reducing the size), or prices may continue to increase. In the latter instance, increased prices will have some impact on demand as shown by the rough relationship between price and demand in Figure 24. There appears to be a discernable increase in sales as the price decreases. However, the

Figure 22
Average price per book (1960-1980)



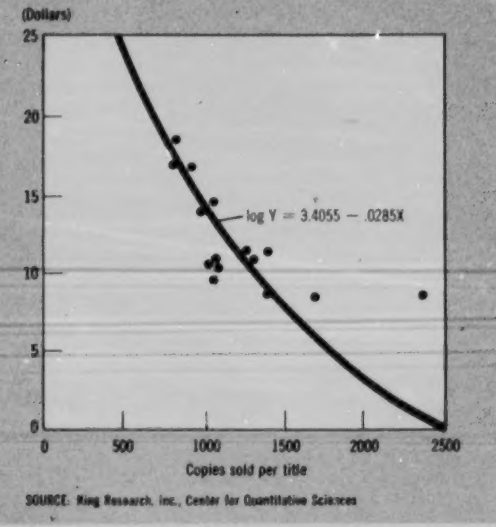
SOURCE: R. R. Bowker Company (1960-1974)
King Research, Inc., Center for Quantitative Sciences

Figure 23
Average receipts per book title (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 24
Price versus demand for S&T books



SOURCE: King Research, Inc., Center for Quantitative Sciences

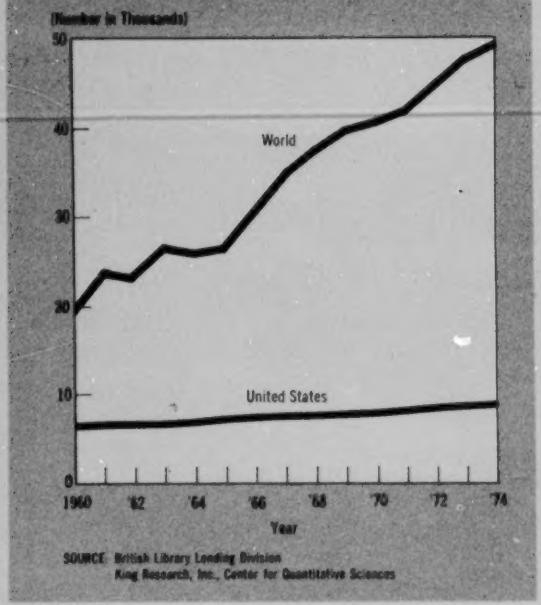
logarithmic relationship depicted in the figure does not appear to be a particularly good one because of the one outlier at 2400 copies sold.

Growth of the Scientific and Technical Journal Literature in the United States

There are not complete data available for the total number of S&T periodicals published in the U.S. from 1960 to 1974. However, by piecing together data from the Library of Congress in the U.S. and the British Library Lending Division, estimates are derived for the growth of number of periodicals published in the world and in the U.S. as shown in Figure 25.

The growth of the number of periodicals published worldwide is substantially greater than that observed for the U.S. The number of

Figure 25
Number of world and U.S. S&T journals published



SOURCE: British Library Lending Division
King Research, Inc., Center for Quantitative Sciences

periodicals published worldwide increased from 18,800 to 49,400 from 1960 to 1974 which represents a 163 percent increase. However, the number of U.S. periodicals increased only from 6,300 in 1960 to 8,500 in 1974 which is a mere 34 percent increase, or an average of 2.1 percent increase per year. According to Price**[9]** one should expect that scientific publishing in developing countries grows rapidly and this growth dampens as countries such as the U.S. become more developed.

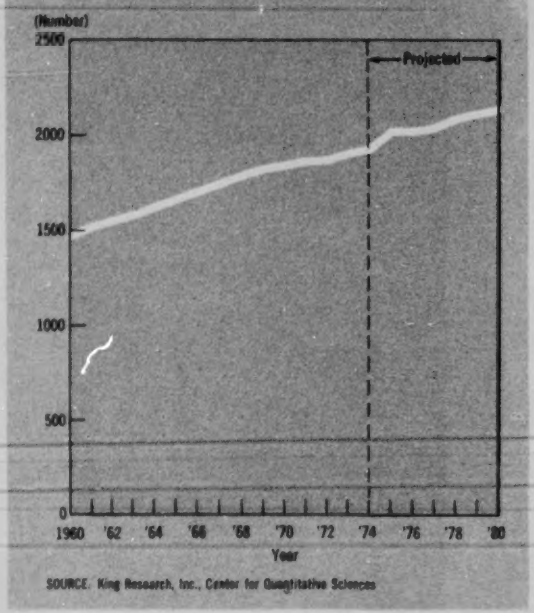
Many of the periodicals covered in the numbers given above are trade journals and other periodicals that are not considered to be scholarly S&T literature. In 1974, Indiana University, under a grant from NSF, identified a core set of scholarly journals published in the U.S.**[4]** As part of this indicator study, a sample of these journals was studied by us and tracked back to 1960 to establish their birth rates. Another sample of scholarly journals was drawn from journals published in 1960 and tracked forward to determine corresponding death rates. From these processes, the number of scholarly journals was estimated from 1960 to 1974[5] to be as indicated in Figure 26 below.

The number of scholarly journals increased from 1,490 in 1960 to 1,945 in 1974 and is forecast to continue steady growth to 2,140 in 1980. The growth in number of scholarly journals from 1960 to 1974 was 30 percent and the average annual rate of growth is estimated to be 1.9 percent. Thus, the rate of growth of all S&T periodicals and S&T scholarly journals is about the same in the U.S. over the 1960 to 1974 period.

The estimated growth of number of journals varies substantially among the nine fields of science. These trends are shown in Figure 27. Nearly all of the fields of science experienced close to linear growth from 1960 to 1974. The one outstanding exception to this trend is in the field of engineering where the sample of journals was observed to decrease substantially in numbers from 1967 to 1971.

A better statistical indicator of the growth of the journal literature in the U.S. is the number

Figure 26
Number of scholarly S&T journals published in the U.S. (1960-1980)

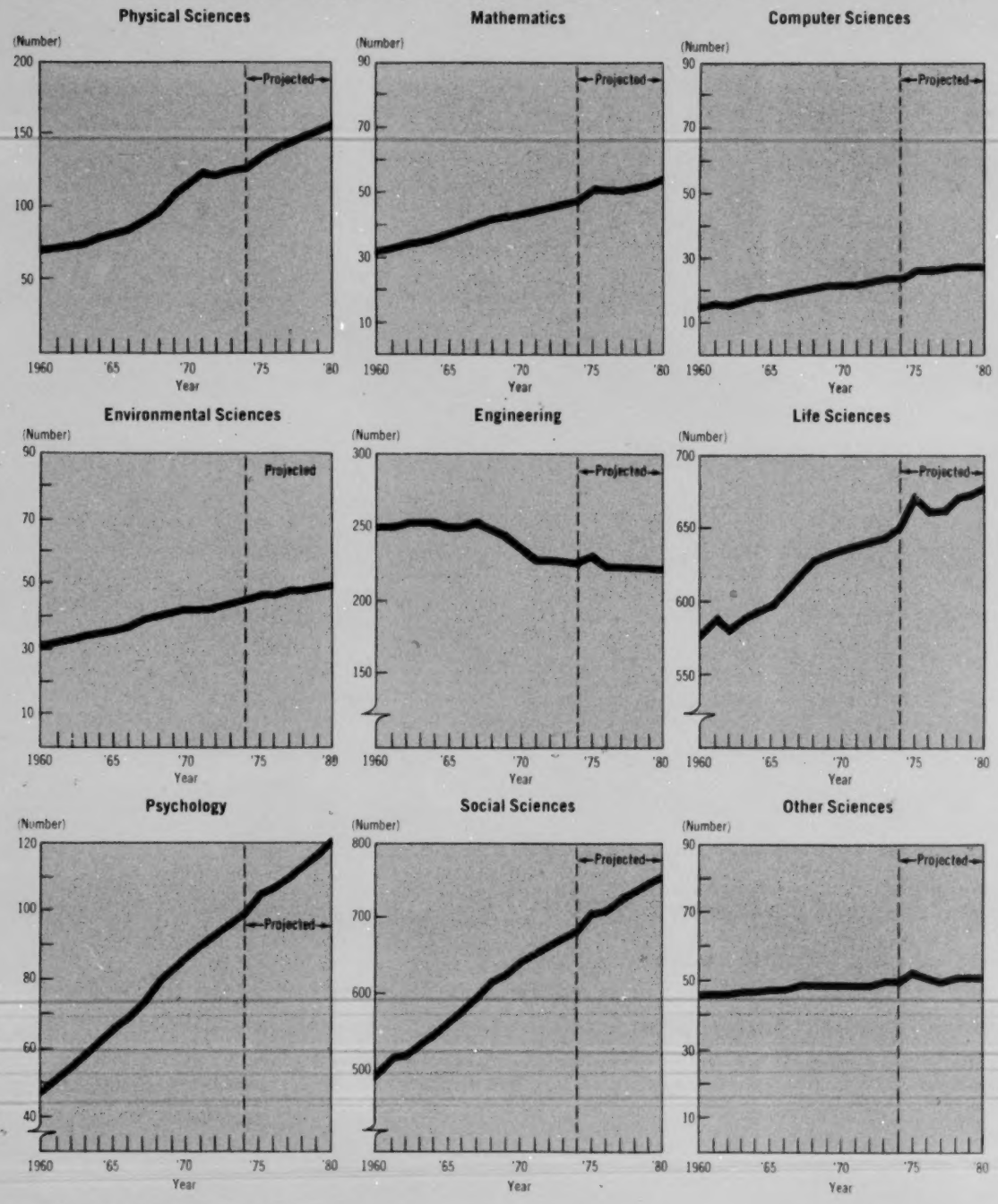


SOURCE: King Research, Inc., Center for Quantitative Sciences

[5] From this point out, data apply only to scholarly journals as depcited by the universe of scholarly journals identified in the Indiana University study.

Figure 27

Number of scholarly S&T journals published in the nine fields of science (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

of journal articles published which is displayed in Figure 28.

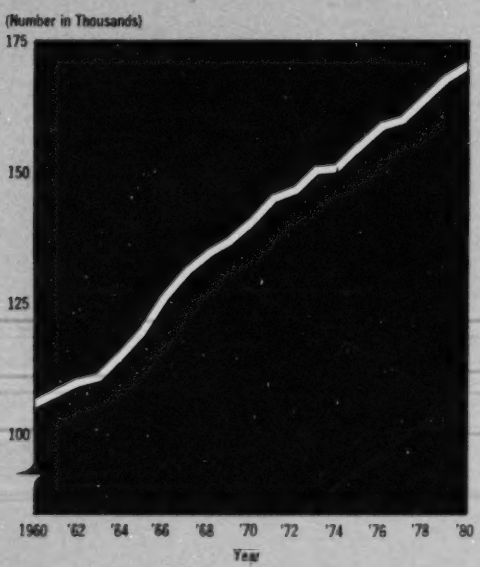
The total number of scholarly articles has increased from 106,000 in 1960 to 151,000 in 1974 which is a 42 percent increase. The number of articles has increased at a slightly greater rate than number of journals since the number of articles per journal was estimated to be 71 in 1960 and increased to 77 in 1974.

The number of scholarly journal articles published is highly correlated to the number of scientists, which is depicted in Figure 29. The number of scientists and engineers is lagged one year to account for the delays in publishing scholarly journal articles.

The simple regression equation shown in Figure 29 was used to forecast number of scholarly articles published from 1975 to 1980. The number of scholarly journal articles was also related to other variables such as number of scientists holding doctoral degrees (r^2=0.97), and R&D funding lagged 3 years (r^2=0.89). Thus, all three variables are highly correlated to number of articles published in the U.S.

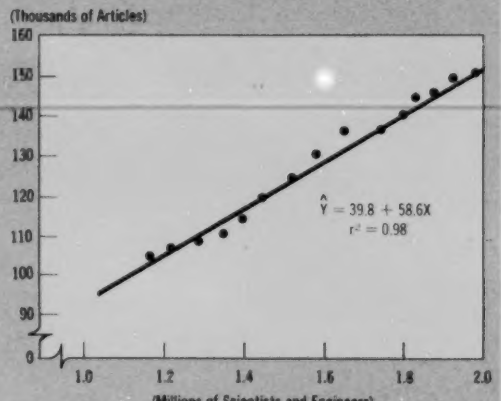
Even though there is very high correlation between number of scholarly journal articles and number of scientists, it is found that the number of scholarly articles written per scientist declined slightly, but steadily from 0.091 in 1960 to 0.076 in 1974. Viewed in another way, there were 10.9 scientists per scholarly article published in 1960 and 13.1 scientists per scholarly article published in 1974. This number is expected to remain about the same up to 1980.

Figure 28
Number of scholarly S&T articles published (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 29
Number of scholarly S&T journal articles as a function of scientists and engineers



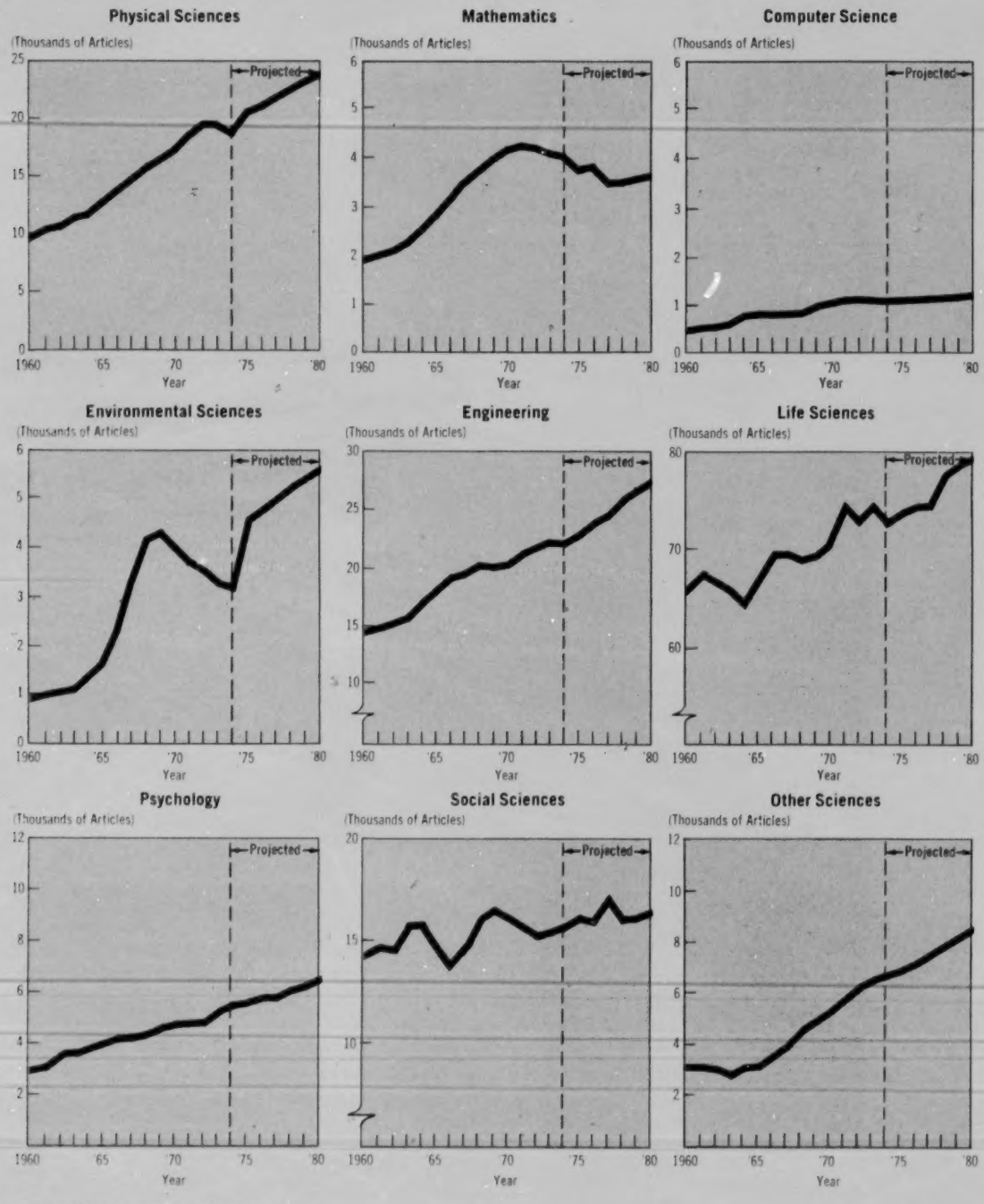
SOURCE: King Research, Inc., Center for Quantitative Sciences

The variation of numbers of articles published among fields of science is even greater for scholarly articles than for scholarly journals. This is due partially to differences in the number of articles per journal among the fields. The estimated total number of scholarly articles published in the nine fields of science from 1960 to 1980 is given in Figure 30.

The greatest increases in growth of scholarly articles published from 1960 to 1974 occurred in the Environmental Sciences (241 percent for an average annual increase of 9.2 percent), and the Computer Sciences (139 percent for an average annual increase of 6.4 percent). The average growth of all fields of science is expected to be 11 percent from 1975 to 1980. Mathematics is forecast to have a decrease in growth of 2.2 percent over that period of time. The remaining fields of science are expected to continue growth with the greatest growth expected in Environmental Sciences (24 percent) and Engineering (19 percent).

Figure 30

Number of scholarly journal articles published in nine fields of science (1960-1980)



SOURCE: King Research Inc., Center for Quantitative Sciences

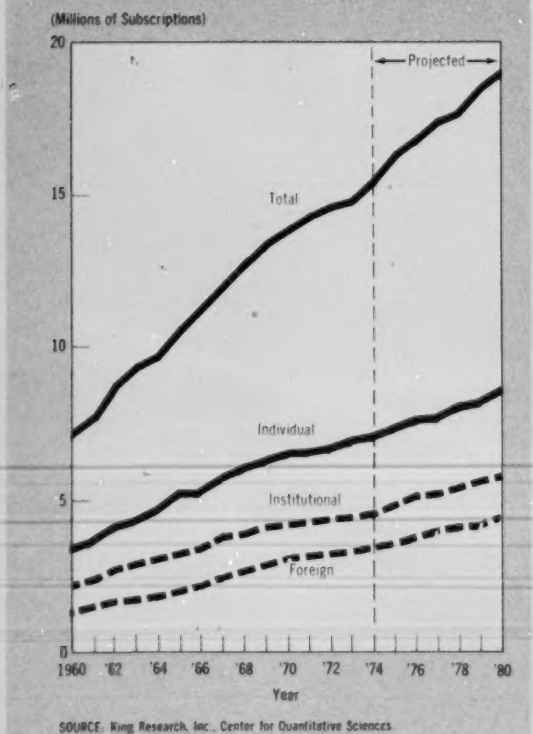
While there appears to be potential (if not existing) economic difficulties in book publishing, journal publishing seems much healthier even though there are trouble spots throughout the industry. In the absence of available published data, the number of journal subscriptions was estimated from a nonrandom sample of 173 scholarly journals. Estimates from these observations indicate a steady increase in number of subscribers overall. However, in some instances individual journals showed a decline. The estimated number of foreign, domestic individual and domestic institutional subscriptions are given in Figure 31. These estimates indicate that the three forms of subscriptions exhibit a nearly linear growth from 1960 to 1974. The total number of individual subscriptions was estimated to be 3,500 in 1960 and rising to 7,100 in 1974 which represents a 103 percent increase. Institutional subscriptions had a similar growth from 2,300 in 1960 to 4,600 in 1974. The relative proportion of subscriptions from 1969 to 1973 were based on the Indiana University study.

The trend in growth of subscriptions is expected to continue since magnitude of both individual and institutional subscriptions is a function of the number of scientists. For example, the number of individual subscriptions per scientist was 3.0 in 1960 and rose slightly to 3.6 in 1974. The forecasts of number of institutional subscriptions and total domestic subscriptions are based on high correlation of number of subscriptions with number of scientists. These relationships are shown in Figures 32 and 33.

Another statistical indicator is the number of scholarly articles distributed per scientist by means of institutional and individual subscriptions and by reprints from authors. These estimates are exhibited in Figure 34.

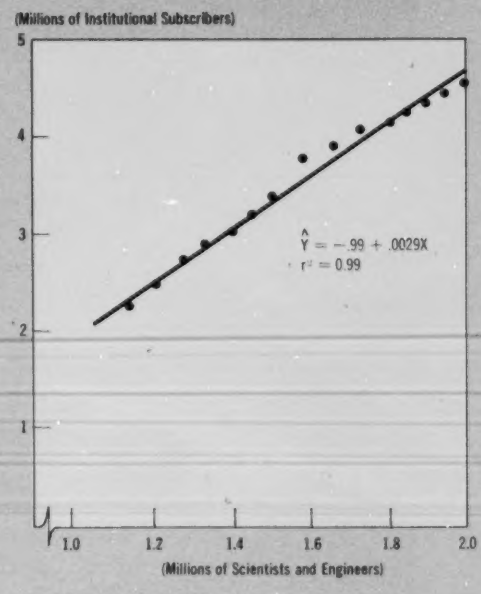
There are about half again as many articles distributed by individual subscriptions as by institutional subscriptions. Distributing ar-

Figure 31
Number of scholarly S&T journal subscriptions (1960-1980)



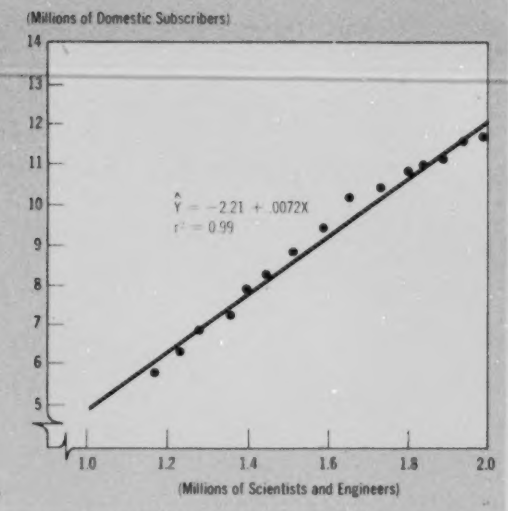
SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 32
Number of institutional journal subscriptions as a function of the number of scientists and engineers



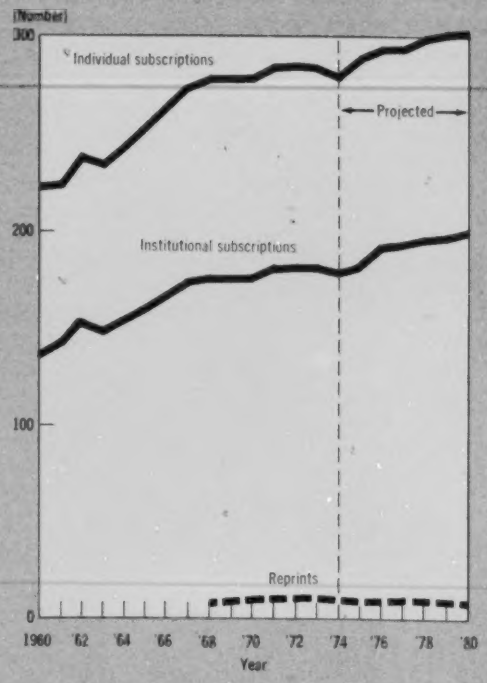
SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 33
Number of domestic journal subscriptions as a function of the number of scientists and engineers



SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 34
Distribution of journal articles to scientist by individual and institutional subscriptions and reprints (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

ticles by reprints barely exists by comparison. However, many of the articles that are distributed, say, by individual subscription, are not read by the subscriber. Therefore, when considering use of articles a different picture emerges.

A survey was made as part of this statistical indicators study to determine relative use of articles for the purpose of citing in journal articles.[6] The following percentages refer to the source from which cited articles were obtained.

- Individual subscriptions—27.2 percent ± 1.5 percent[7]
- Insitutional subscriptions—47.4 percent ± 1.6 percent
- Reprints—25.3 percent ± 1.4 percent

A statistical indicator of relative efficiency of these three modes of transferring scholarly journal articles is the number of articles distributed by each means per article cited. Results are as follows:

- Individual subscriptions—2,240 articles distributed per article cited
- Institutional subscriptions—820 articles distributed per article cited
- Reprints—30 articles distributed per article cited

Thus, reprints appear to be the most effective means of distributing articles to authors with institutional subscriptions substantially more effective than individual subscriptions.

The cost per article cited presents another useful statistical indicator for comparing the cost-effectiveness of the three modes of distributing S&T journal articles. Total cost of each distribution mode includes all costs such as those incurred in reproduction, initial

[6] Some cited articles were obtained second hand from colleagues who had initially obtained their copies by subscription, libraries, or reprints.

[7] Approximate standard error achieved from a sample of 943 responses. Response rate was 44 percent.

distribution, acquisition, storage, organization and control, identification and physical access to articles. The total costs per article cited for the three modes of distributing articles are as follows:

- Individual subscription—$7.00 per article cited
- Institutional subscriptions—$6.50 per article cited
- Reprints—$3.80 per article cited

Reprints also seem to be the most cost-effective mode of distributing articles when considering total cost per article cited. Individual subscriptions and institutional subscriptions are remarkably close in this measure of cost-effectiveness.

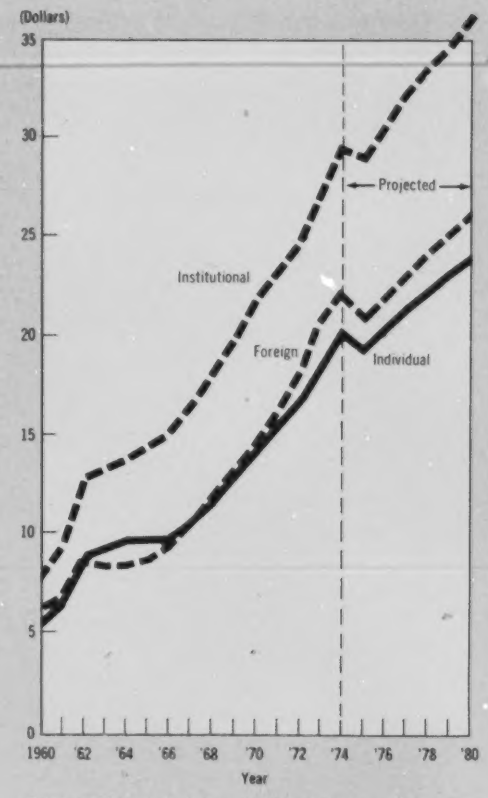
The subscription prices for journals were estimated from the sample of S&T scholarly journals. As shown in Figures 35 and 36, these prices have increased substantially in constant dollars as well as in current dollars for foreign, insitutional and individual subscriptions.

Average prices to the three types of subscribers rose at about the same pace from 1960 to 1974. The individual prices rose 281 percent from $5.27 to $20.08. Whereas, insitutional prices increased 275 percent from $7.88 to $29.57. Prices to foreign subscribers increased from $6.01 to $21.90 for an increase of 264 percent. Therefore, even though there is a price differential among the three types of subscriptions, the rate of increase among them is about the same.

The average scholarly journal subscription prices are given for the nine fields of science in Figures 37 and 38 for institutional subscription prices and for individual subscription prices. The highest prices tend to be with the Physical Sciences and Mathematics which might be expected since publications in these two fields of science require a great amount of special characters and graphics which are very expensive. On the other hand, the prices are low in fields of science which have publications that commonly have straight text.

Since the number of articles per journal and the number of pages per article are changing over time, perhaps a better indicator of price is the price per article and price per kiloword page. These two prices charged to individuals are given in Figures 39 and 40 in current and constant dollars.

Figure 35
Average institutional, individual, and foreign subscription prices in current dollars (1960-1980)



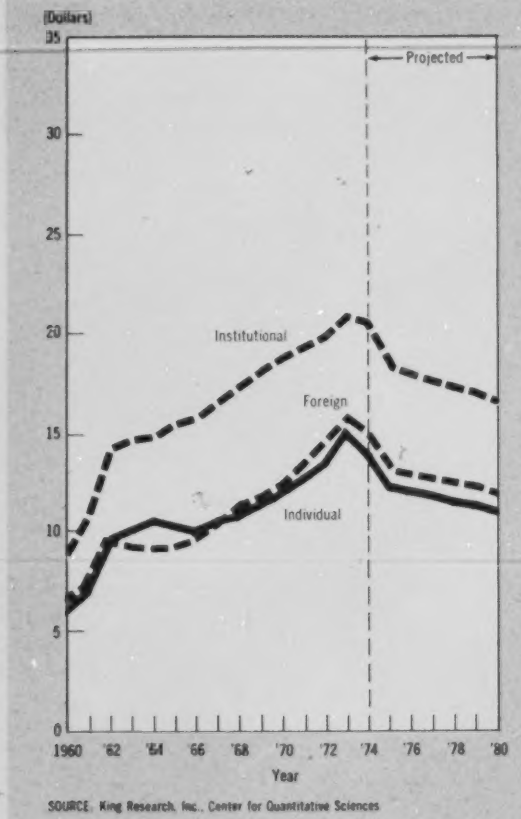
SOURCE: King Research, Inc., Center for Quantitative Sciences

Both the price per article and price per kiloword page have remained relatively stable in constant dollars over the period from 1962 to 1971. These prices begin to rise up to 1974. In the future, a decrease in price (in constant dollars) is anticipated.

Growth of the Scientific and Technical Report Literature in the United States

There are two principal sources of S&T report literature produced under Federal Government sponsorship. The first of these is the National Technical Information Service (NTIS), which serves a number of government agencies in reproducing and distributing their

Figure 36
Average institutional, individual, and foreign subscription prices in constant dollars (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

report literature. The second major source of Federal Government sponsored report literature is the U.S. Government Printing Office (GPO). Data were obtained from both agencies back to 1965. The very large growth of number of items processed by NTIS is shown in Figure 41.

The number of reports processed by NTIS increased from 14,000 in 1965 to 61,100 in 1975. Forecast of NTIS growth is made by simple time series analysis which shows an expected increase to 84,800 reports processed in 1980. Much of the past growth in NTIS has been due to expanded coverage so that this trend in coverage must continue for the forecast to hold. This growth in coverage is attributable to aggressive acquisition by NTIS.

The GPO also reproduces and distributes government sponsored research reports. They process substantially fewer reports than NTIS but their reports have wider distribution on the average. A sample of approximately 40 S&T reports[8] was drawn from the *Monthly Catalog* for each year from 1965 to 1974. From this sample such information as price, subject field, number of pages and number of copies distributed was noted. Over one-half of the S&T GPO reports are available at NTIS, so that the remainder are those reproduced and distributed primarily by GPO. There has been a substantial growth in S&T reports submitted to GPO over the period 1965 to 1974. This growth is illustrated in Figure 42.

The growth was from 750 in 1965 to 1,960 in 1974 which represented a 162 percent increase or an average of 11 percent per year. The forecast from 1975 to 1980 shows an additional growth of 24 percent.

The relationship between number of reports input in one year and the number of copies sold the following year[9] is shown in Figure 43 for NTIS. The relationship has a high correlation (r^2=0.96) and is used as a basis for forecasting total copies.

Part of the sales of reports at NTIS is in paper copy and part is in microform. The copy sales for paper copy and microform is also given in Figure 44. From 1966 to 1974 the number of microform sales has increased by an impressive 465 percent while the number of paper copy sales has increased by only 51 percent. The trends should continue with microform sales expected to increase 36 percent from 1975 to 1980 and paper copy sales are expected to increase somewhere near 31 percent during this time period.

Average prices at NTIS for paper copy and microform are given in Figure 45 with linear forecasts of their prices up to 1980.

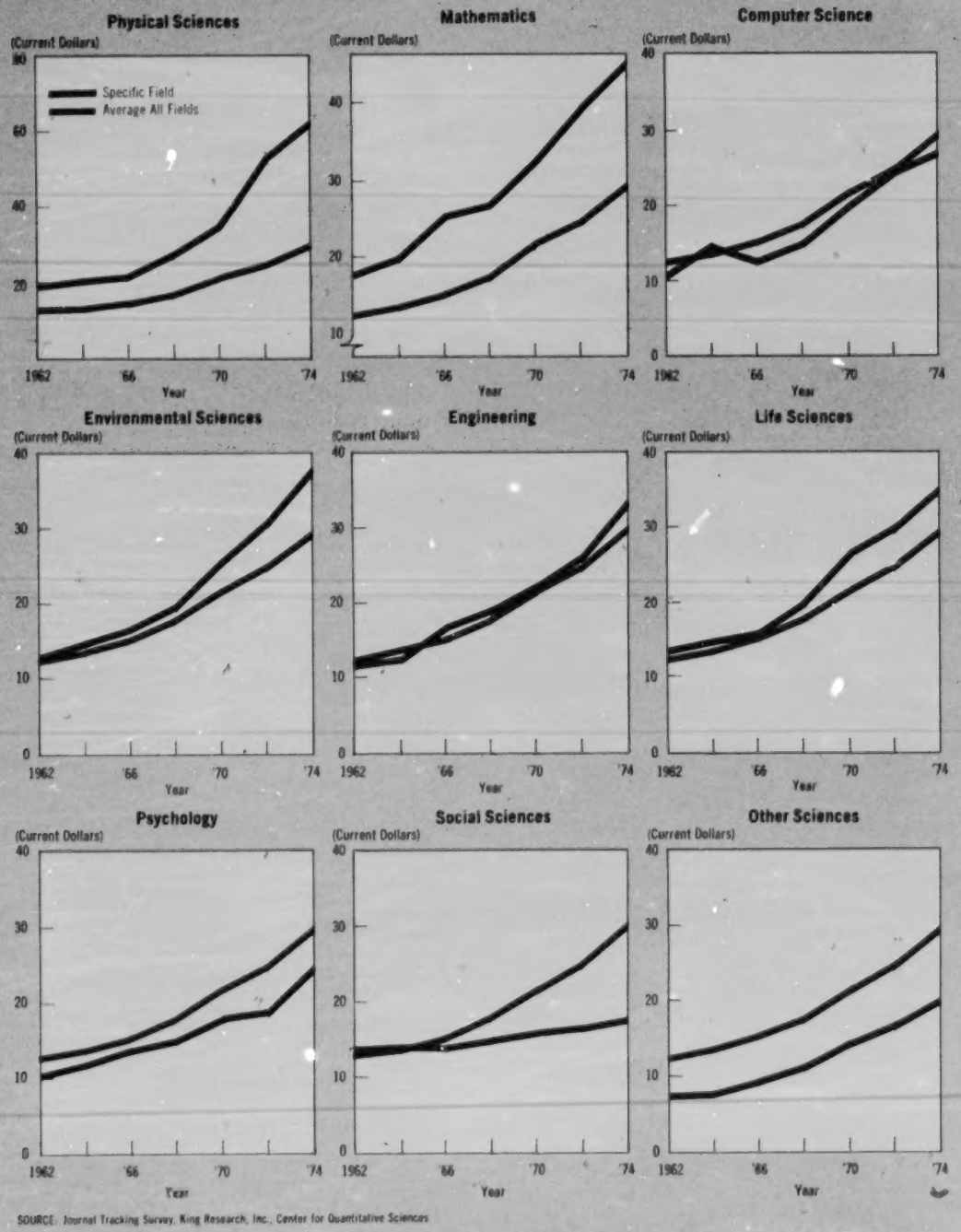
Current dollar price increases for paper copy and microform copy are 232 percent and 97 percent, respectively, from 1966 to 1974. Constant dollar price increases were 123 percent and 26 percent respectively. The large

[8] Only reports that were judged to be written by scientists and engineers for their peers were included. Reports that were written for distribution to the general public were not included.

[9] Past experience has shown that a large proportion of the sales of reports occurs in the first year (even though sales can actually occur as much as 5 years hence.)

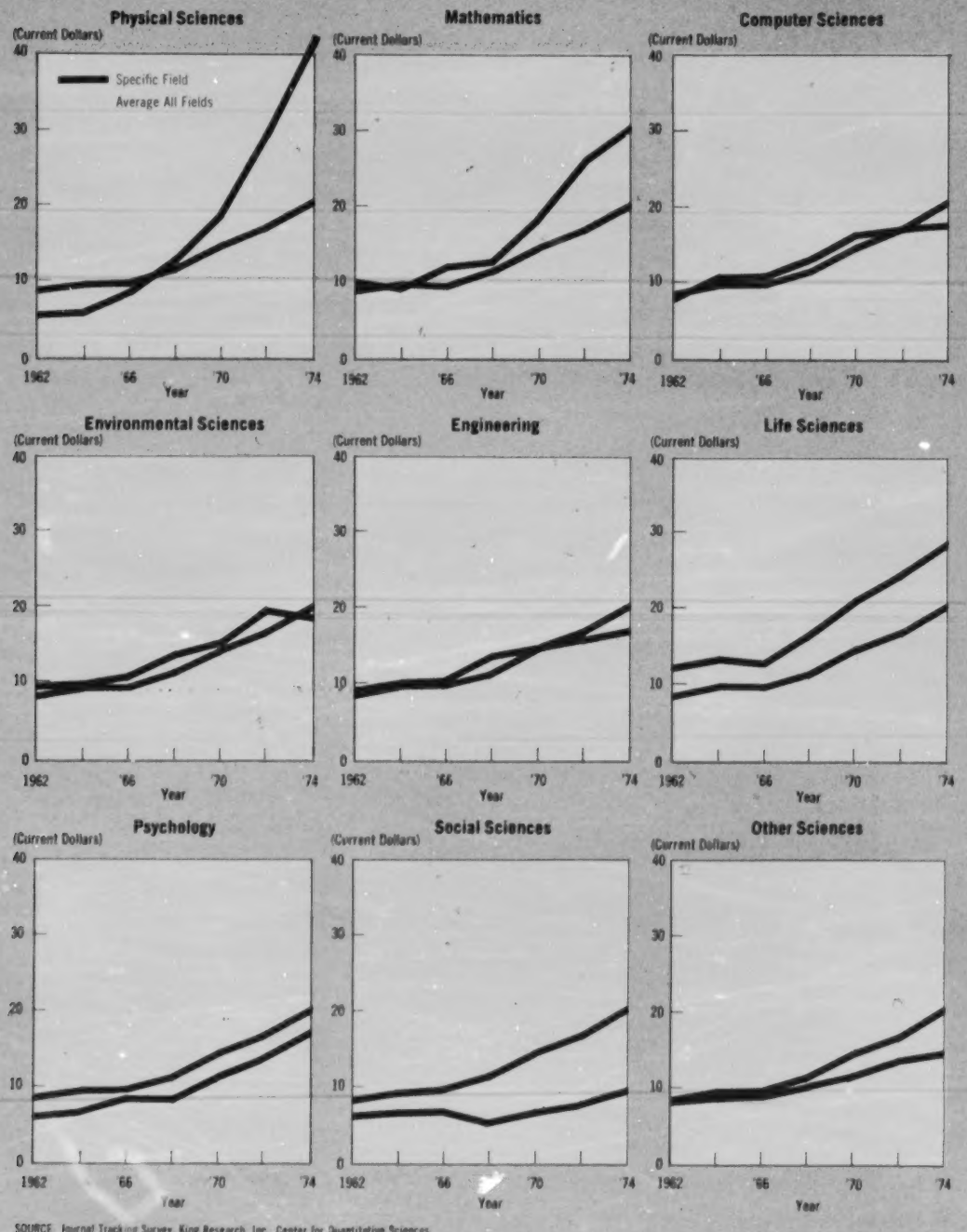
Figure 37

Institutional subscription price for nine fields of science (1962-1974)



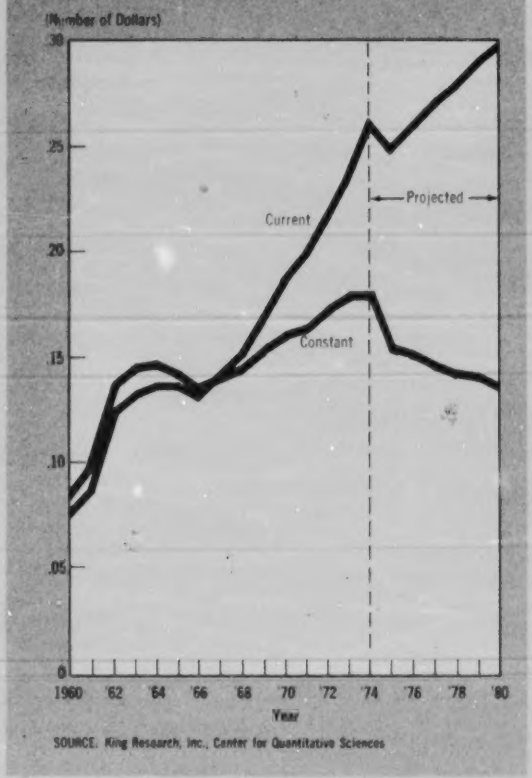
SOURCE: Journal Tracking Survey, King Research, Inc., Center for Quantitative Sciences

Figure 38
Average individual subscription price for nine fields of science (1962-1974)



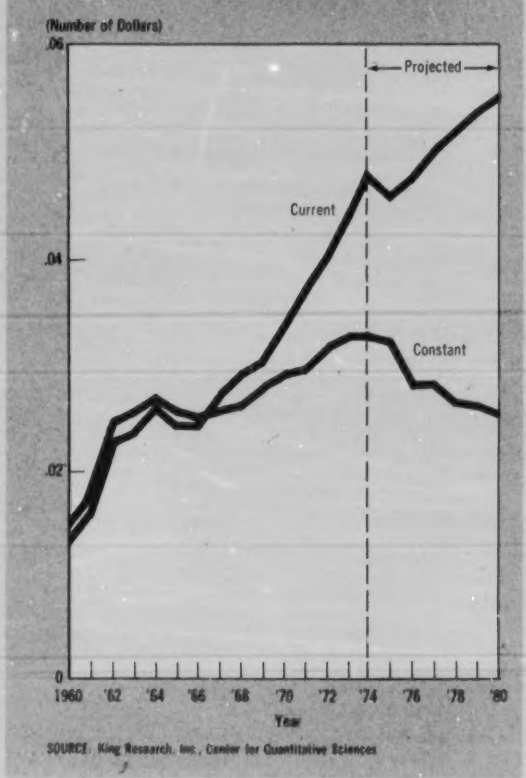
SOURCE: Journal Tracking Survey, King Research, Inc., Center for Quantitative Sciences

Figure 39
Average price per S&T article



SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 40
Average price per kiloword page



SOURCE: King Research, Inc., Center for Quantitative Sciences

difference in price changes might partially contribute to the discrepancy observed in paper copy and microform sales over the years. The average sales per report of paper copy is roughly estimated by dividing number of reports (lagged 1 year) into the number of paper copies sold. The average number of paper copies sold is plotted against the average price of paper copies in constant dollars in Figure 46.

This graph shows a rough relationship with average demand and price (in constant dollars). Obviously, price is not the only factor that has dampened paper copy sales at NTIS but it must contribute to this phenomenon.

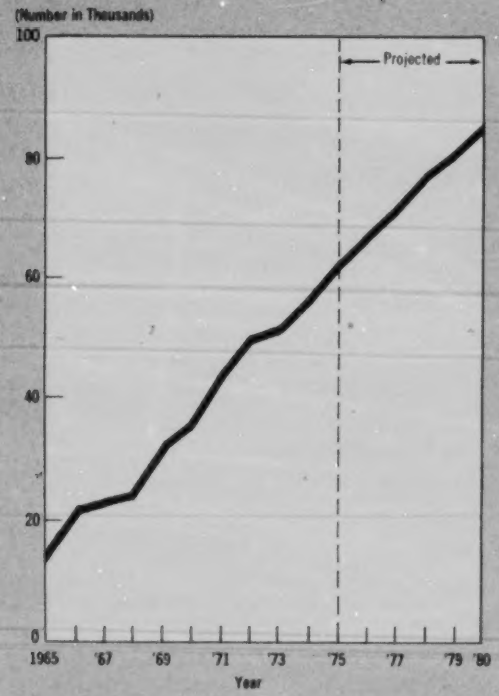
The average number of copies sold per report at GPO also increased from 1,210 in 1965 to 1,630 in 1974 which is an estimated 35 percent increase or about 3.4 percent per year. These averages are plotted in Figure 47 below.

The estimated average price per copy remained relatively constant until 1973 when the price increased somewhat. This increase is reflected in both price per copy and price per page. In 1973 and 1974 the price per page nearly doubled over the previous 8 years. The 3 year moving average price is shown in Figure 48.

If 1973 and 1974 prices represent a policy change, then the forecasts given may be low and, therefore, the estimates of revenue may be low as well, depending on the impact of increased price on future demand. The overall revenue to GPO from sales of S&T reports increased by 521 percent since 1965 or an average of 22 percent per year.

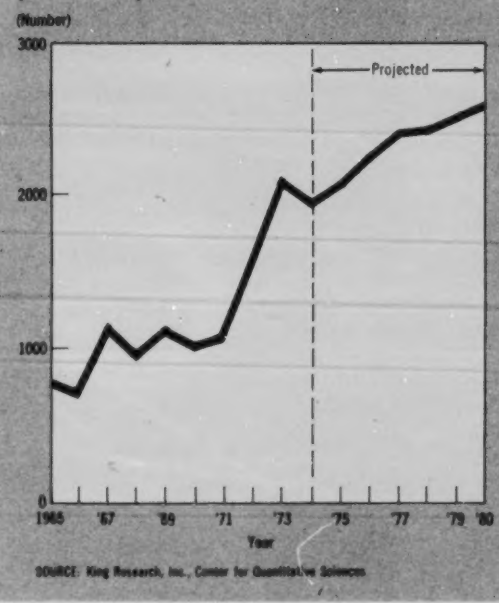
In summary, it appears that reproduction and distribution of S&T report literature, as represented by NTIS and GPO, are growing substantially and should continue to do so

Figure 41
Number of S&T reports processed by NTIS (1965-1980)



SOURCE: National Technical Information Service (1965-1975)
King Research, Inc., Center for Quantitative Sciences (1976-1980)

Figure 42
Number of Non-NTIS S&T reports processed by GPO (1965-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

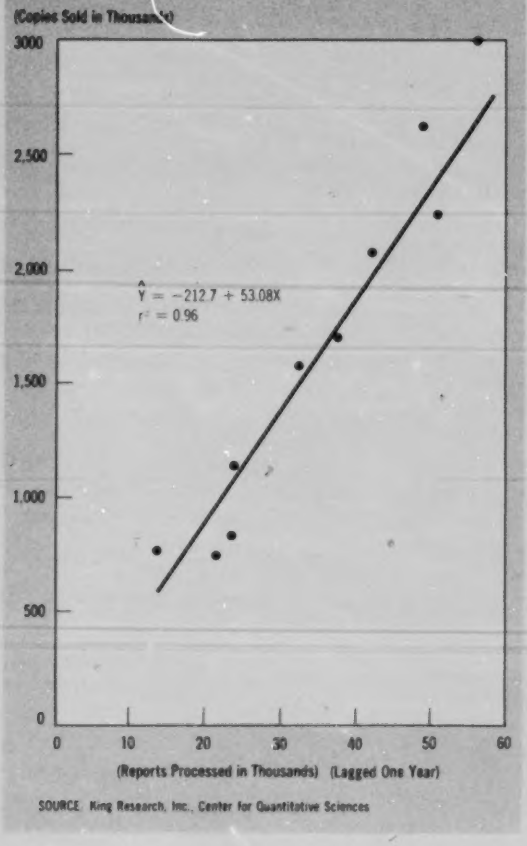
over the next 5 years. One of the most significant phenomenon is the large increase in microform sales at NTIS accompanied by rather stagnant paper copy sales. Even though overall volume seems to have decreased at GPO over the past 10 years, the volume of S&T report literature has made healthy advances.

Growth of Other Forms of Scientific and Technical Literature in the United States

A form of communication that is particularly important in S&T is the conference and an important form of literature publication is the proceedings of such conferences. Some figures on the growth of published conference proceedings in S&T are given in Figure 49. These figures cannot be taken as truly accurate indicators of the number of conference proceedings published each year on a worldwide basis since they represent the number of proceedings published for conferences held each year as identified by the staff of the *Directory of Published Proceedings* as of January, 1975. The publishers are continuing to find additional proceedings for various years of this period (in fact, the published proceedings may appear some years after the conference was held). The figures for the earlier years are relatively stable whereas the figures for the later years (1971 to 1973) are undoubtedly incomplete at present. The figures do reveal a steady increase from 1,726 in 1965 to 2,419 in 1971, which presumably reflects a growth in the number of conferences held internationally, as well as the number of published proceedings available. These figures, although they do indicate growth rate in a crude sense, are known to be very low. The British publication *Index of Conference Proceedings Received by NLL* is growing at the rate of about 7,000 items a year. However, this figure also includes publications from fields other than science and technology.

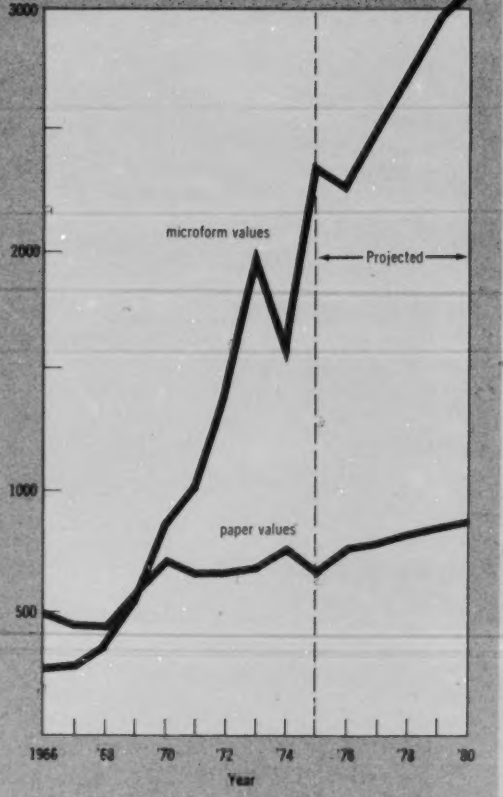
The growth of the U.S. patent literature, in the period 1960 to 1974 is indicated in Figure 50.

Figure 43
Number of copies sold of NTIS reports as function of number of reports (Lagged one year)



SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 44
Paper copy and microform report sales at NTIS (1966-1980)



SOURCE: National Technical Information Service (1965-1975)
King Research, Inc., Center for Quantitative Sciences (1976-1980)

In 1960 the number of patent applications was 84,500. In 1974 this number was 108,000 which was 28 percent greater than the number applied for in 1960. The number of patents issued in 1974 was about 80,000 which was approximately 60 percent greater than the 50,000 issued in 1960. Thus, the patent literature of the U.S. seems now to be growing at approximately an average annual rate of about 3.4 percent per year.

The growth of the dissertation literature is reflected in data presented in Figure 51.

The number of doctoral degrees awarded in the U.S. from the years 1960 to 1974 has more than tripled. In the same period the number of doctoral degrees awarded in science and engineering increased 150 percent from 3,802 to 9,490, an average annual rate of growth of about 6.8 percent, but has dampened considerably the last 5 years. During this time the number of science dissertations published went from 3,387 to 15,606. Since, in science and engineering (as opposed to the fine arts) the number of degrees awarded should be directly equivalent to the number of dissertations accepted, it is assumed that the U.S. dissertation literature should increase at about 2 percent a year on the average over the next 5 years since that is the rate of increase forecast for doctoral degrees in science and engineering.

Figure 45
Price of paper copy and microform reports at NTIS (1966-1980)

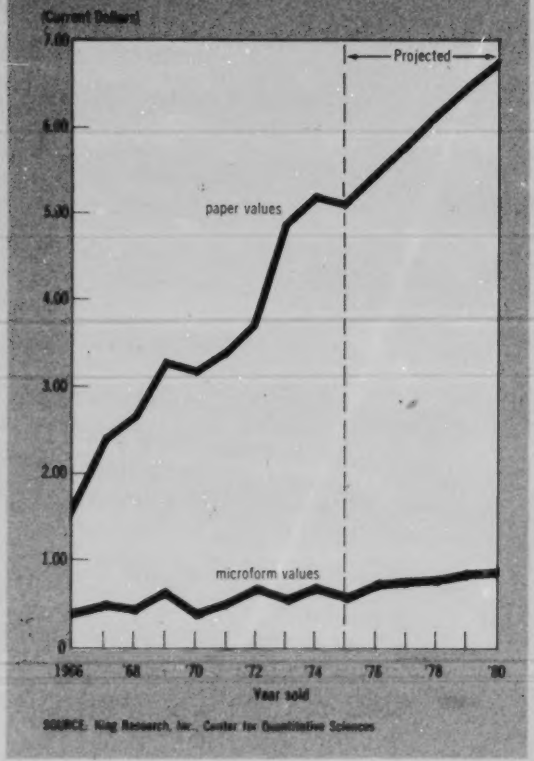


Figure 46
Average number of copies sold as a function of average price for scientific and technical reports sold by NTIS

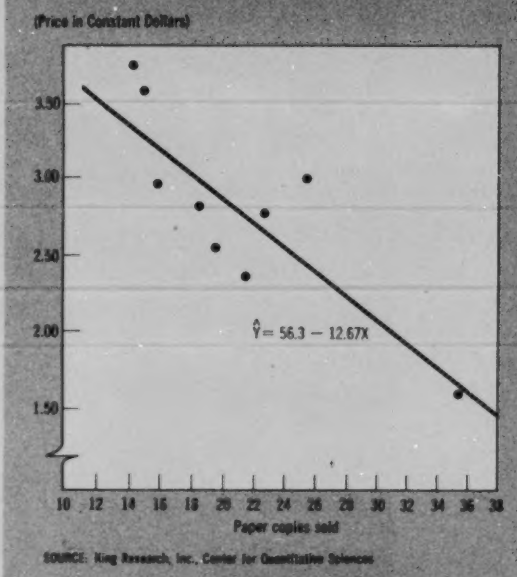
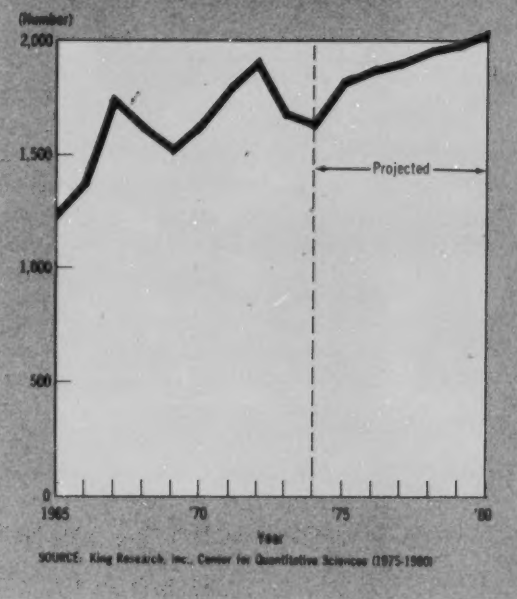

(Price in Constant Dollars)
3.50
3.00
2.50
2.00
1.50
$\hat{Y} = 56.3 - 12.67X$
10 12 14 16 18 20 22 24 26 28 30 32 34 36 38
Paper copies sold
SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 47
Average number of copies sold for scientific and technical reports published by Government Printing Office (1965-1980)

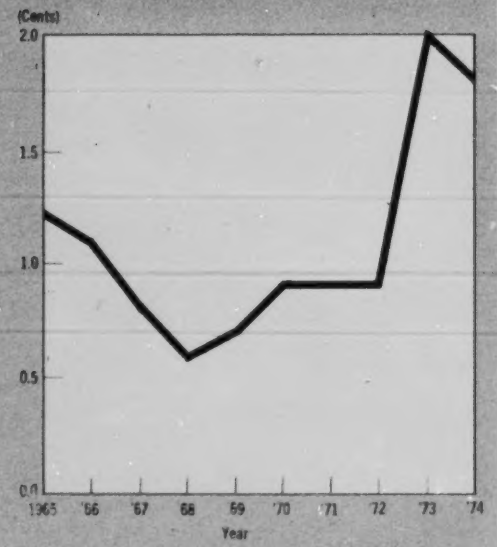


Comparison of Growth Among the Forms of Literature

The overall health of S&T communication is partially determined by the relative strength of the literature forms. Relative growth of the literature forms is given below.

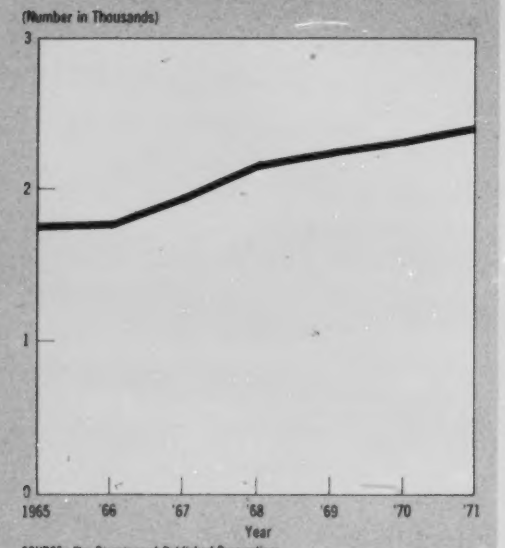
Figure 52 shows that all forms of S&T literature exhibit a steady growth over the period of 1960 through 1974 and there is every indication that this growth will continue through 1980. The estimated number of S&T scholarly journals increased from 1,490 in 1960 to 1,950 in 1974 which represents a 30 percent increase or an average annual increase of 1.9 percent. The number of scholarly journals is expected to increase to 2,140 in 1980. The number of scholarly journal articles published went from about 106,000 in 1960 to 151,000 in 1974, an increase of about 42

Figure 48
Price per page for scientific and technical reports published by Government Printing Office (1965-1974)



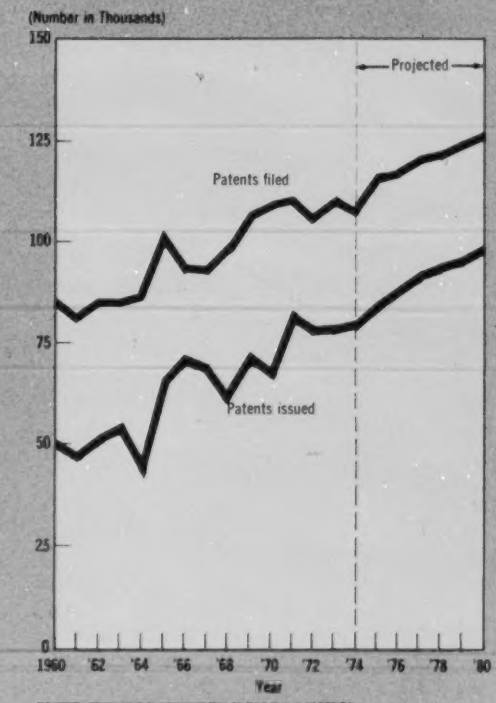
SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 49
Number of published S&T conference proceedings (1965-1971)



SOURCE: The Directory of Published Proceedings, InterDoc Corporation, Harrison, New York

Figure 50
Number of U.S. patent applications filed and issued (1960-1980)



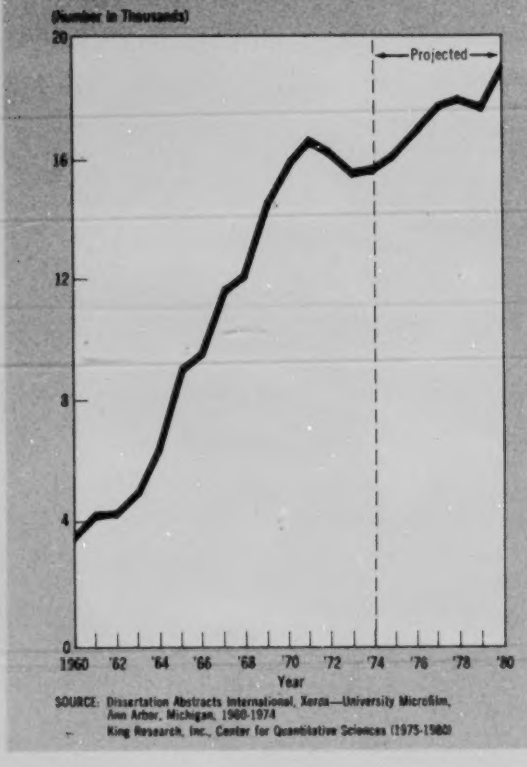
SOURCE: Statistical Abstract of The United States (1950-74)
King Research, Inc., Center for Quantitative Sciences (1975-1980)

percent. The average annual increase is 2.6 percent. When journal publishing is considered in terms of articles, the volume is considerably greater than the other forms of S&T literature.

Number of books written, on the other hand, experienced far greater relative growth than the journal literature in that there were 3,379 book titles published in 1960 and this number swelled to 14,442 in 1974 which is an increase of 327 percent. The average annual rate of increase has been 10.9 percent but this rate is expected to dampen considerably in the future because of the unfavorable economic picture for book publishing which is illustrated by the next two indicators (publication and price).

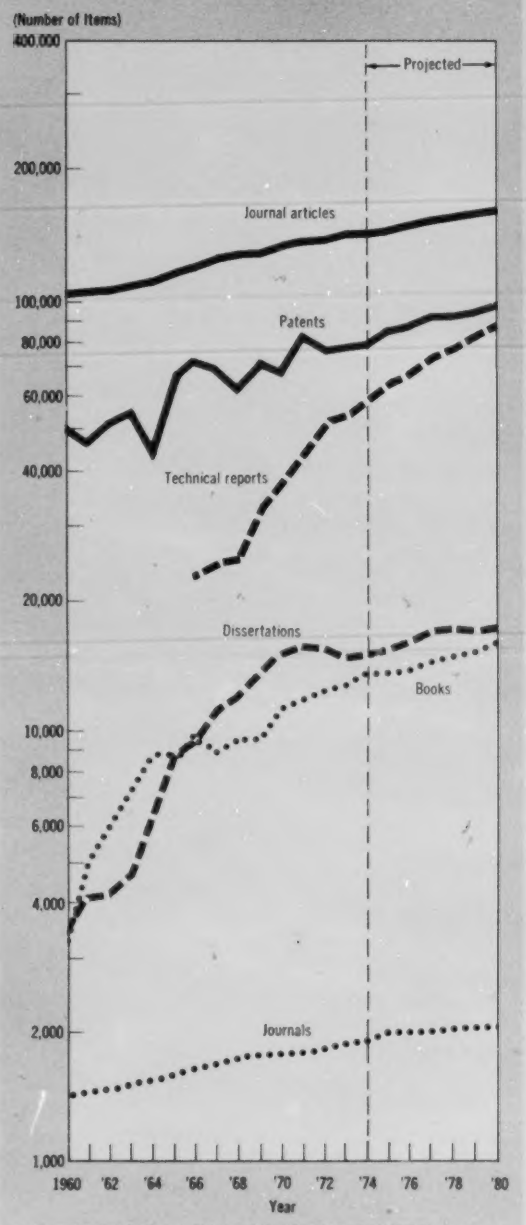
The dissertation literature increased from 3,400 in 1960 to 15,600 in 1974, which is an increase of 361 percent. This represents an average annual increase of 11.5 percent. The future growth which is dependent on number

Figure 51
Number of dissertations published in science and technology (1960-1980)



SOURCE: Dissertation Abstracts International, Xerox—University Microfilm, Ann Arbor, Michigan, 1960-1974
King Research, Inc., Center for Quantitative Sciences (1975-1980)

Figure 52
Growth of U.S. scientific and technical literature forms (1960-1980)



SOURCE: The Bowker Annual of Library and Book Trade Information, R. R. Bowker Company, (Books, 1960-1974)
Dissertations Abstracts International (Dissertations, 1960-1974)
King Research, Inc., Center for Quantitative Sciences (Journals, 1960-1980. All Others, 1975-1980)
National Technical Information Service (NTIS Reports, 1960-1974)
Statistical Abstracts (Patents, 1960-1974)

of doctoral degrees granted should level to about 18,000 in 1980. This growth is nearly parallel to the number of books written. The number of patents issued has increased about 60 percent from about 50,000 in 1960 to 80,000 in 1974. The average annual increase is 3.4 percent. This general trend should continue through 1980.

The number of items written per scientist is displayed in Figure 53. The number of journals published per scientist has remained stable, but slightly decreasing over the years. The number of journals published per scientist was .00129 in 1960 and .00099 in 1974, an average annual decrease of 1.9 percent. This trend is expected to continue up in 1980. There was a rapid increase in average number of books written from .00292 books written per scientist in 1960 to .00732 in 1974, at which time it levelled out. The average annual increase is 6.8 between 1960 and 1974. A

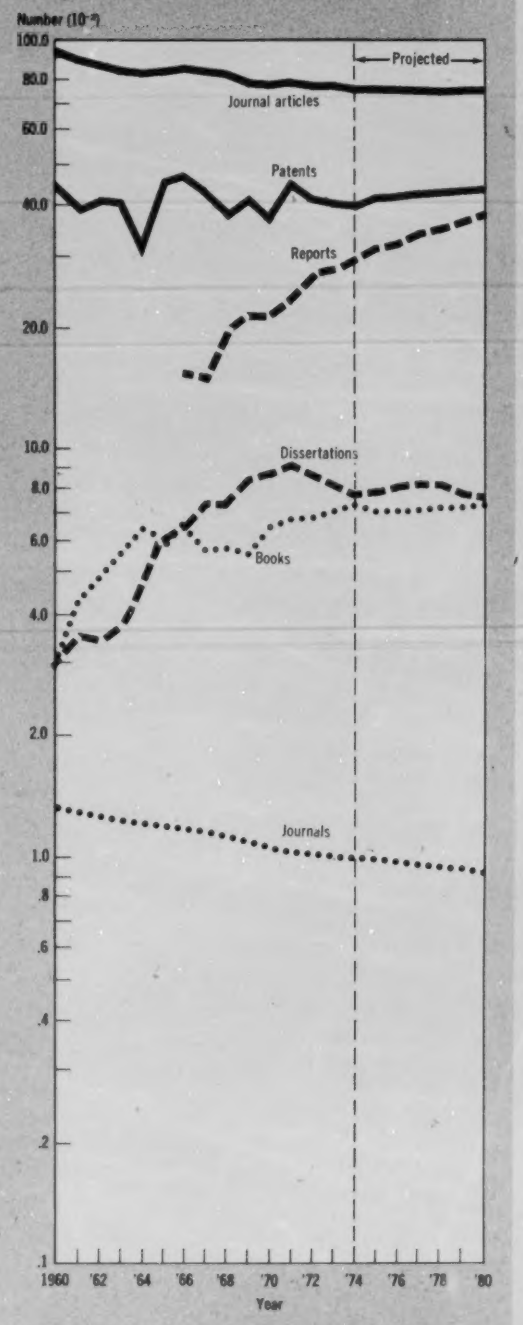
similar growth is observed in dissertations which reflects the number of doctoral degrees awarded over this span of time. The average annual rate of growth for dissertations written per scientist between 1960 and 1974 was 7.4 percent. The annual growth rate for reports between 1966 and 1974 was 8.3 percent. The patent literature produced by scientists has fluctuated somewhat over the years but there is no indication of a general trend either up or down in the past or in the future.

Gross estimates of the cost of writing S&T literature are presented in Figure 54 in current dollars. The average annual rate of increase in costs between 1960 and 1974 for journals, books, dissertations, and patents is 13.9, 16.4, 17.2 and 6.9 percent, respectively. The average annual rate of growth is 23.3 percent for reports between 1965 and 1974. Reports are increasing at a more rapid rate than the other forms of S&T literature.

The number of copies sold per literature item is given in Figure 55. The average number of journal subscriptions increased steadily from 3,900 domestic subscribers per journal in 1960 to 6,000 subscribers in 1974, representing an average annual growth rate of 3.2 percent. This trend is expected to continue at a dampened pace through 1980. Books, on the other hand, experienced an average annual decrease of 7.6 percent in number of copies sold per book from 1960 to 1974. There was a particularly large drop in the early 1960s with the trend continuing downward after that time. In 1960 the number of copies per title sold was 2,400 and this number is down to less than 800 in 1974. The trend in number of copies per report sold has remained relatively flat, although there is a fairly large fluctuation over the years from about 80 to 110. There is no evidence that general trends might change over the next 5 years for any of the three forms of literature.

The number of copies sold per scientist is given in Figure 56. The number of journal subscriptions per scientist has remained relatively constant, with an average annual rate of growth of only 1.3 percent between 1960 and 1974, and is anticipated to remain in the range of 5 to 7 subscriptions per scientist up through 1980. The number of copies of books per scientist has remained between about 6 and 8 in the past but may decline in the future. The average number of copies of

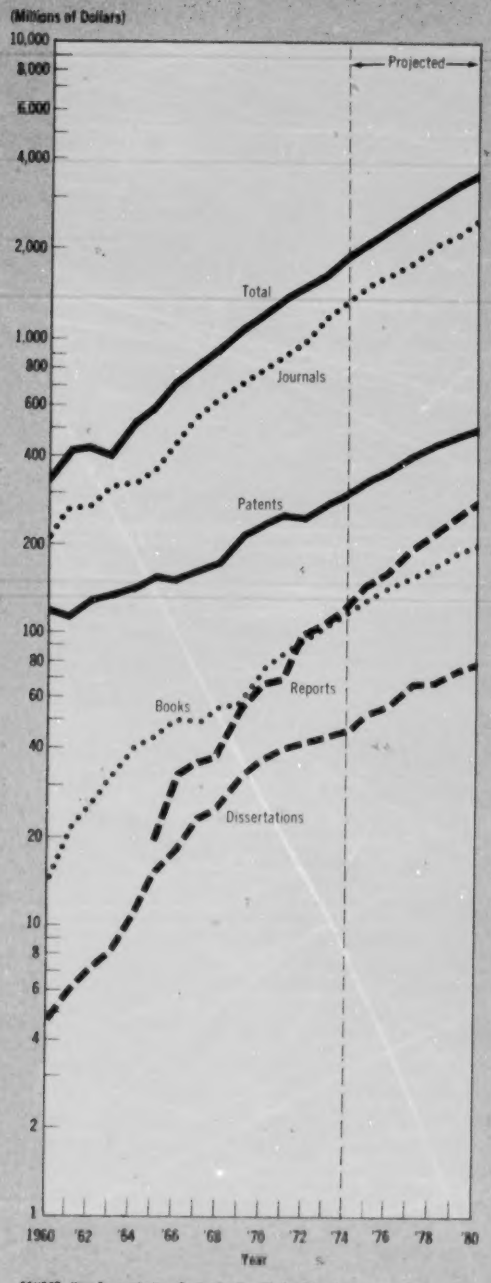
Figure 53
Number of items per scientist or engineer, by medium (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 54

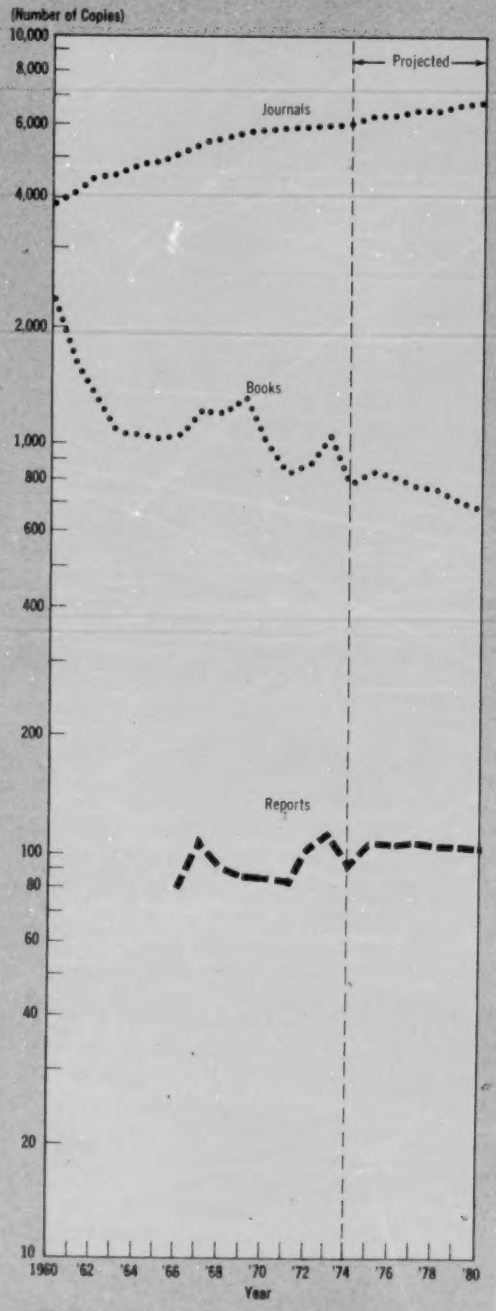
S&T communication resource expenditures for composition and recording, by medium (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

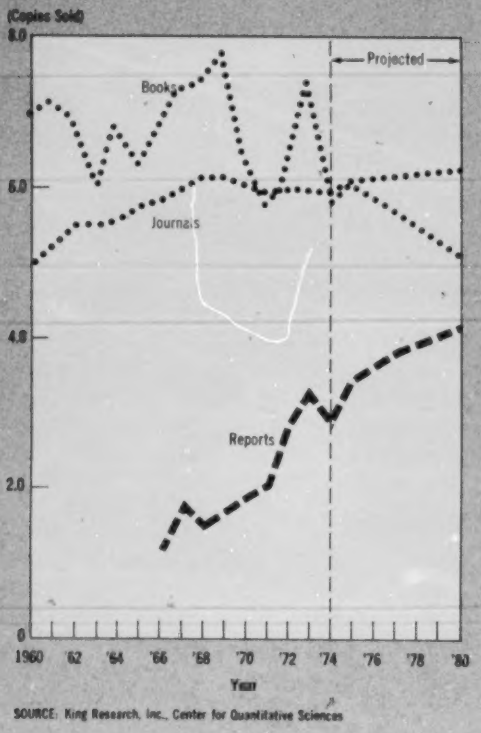
Figure 55

Number of copies sold per item, by medium (1960-1980)



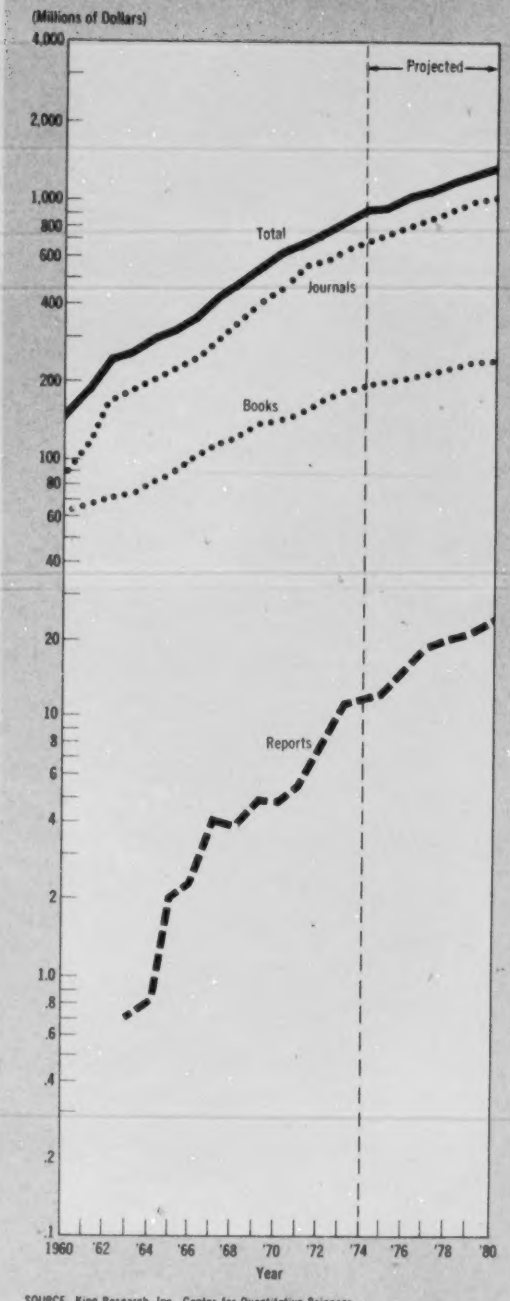
SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 56
Copies sold per scientist or engineer, by medium (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 57
S&T communication resource expenditures for reproduction and distribution, by medium (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

reports has increased substantially with an average growth rate of 11.5 between 1966 and 1974.

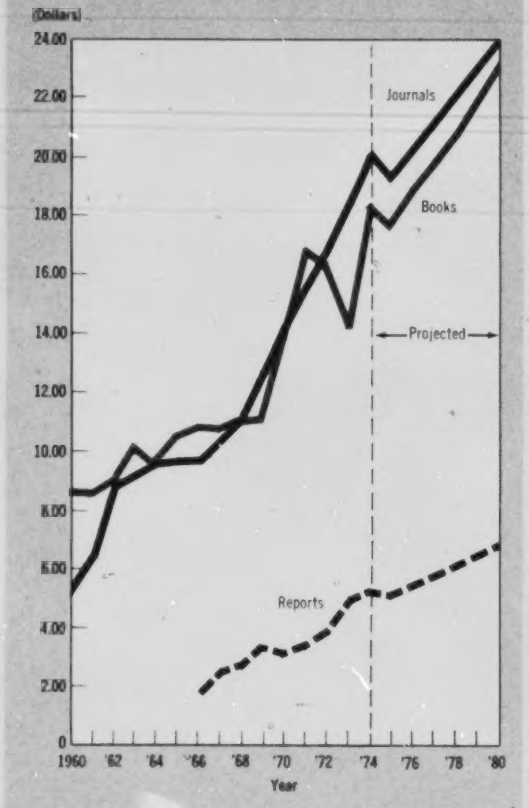
The flat trends of the journal and book forms of literature suggest that there may be an acceptable amount of literature that individual scientists will purchase regardless of the quantity available to them. This appears to be particularly well illustrated by the fact that the number of books written has increased dramatically but the number of copies purchased per scientist has remained nearly level. Since many of the purchases of literature are by libraries, it is expected that future increases in inter-library loaning will have an impact on future number of subscriptions and copies distributed. Increased costs and prices illustrated below will also influence this trend.

The total cost of publication (reproduction and distribution) of S&T literature is given in Figure 57. Journal expenditures grew from $89

million in 1960 to $720 million in 1974, books rose from $66 million to $200 million and reports increased from $700 thousand in 1963 to $12.4 million in 1974. The average annual rate of increase for journals, books, and reports in this time period was 16.2 percent, 8.3 percent and 30 percent, respectively. Report expenditures appear to be growing at a much faster rate than book and journal expenditures, but are forecast to level out after 1974, at an average annual growth rate of 12 percent.

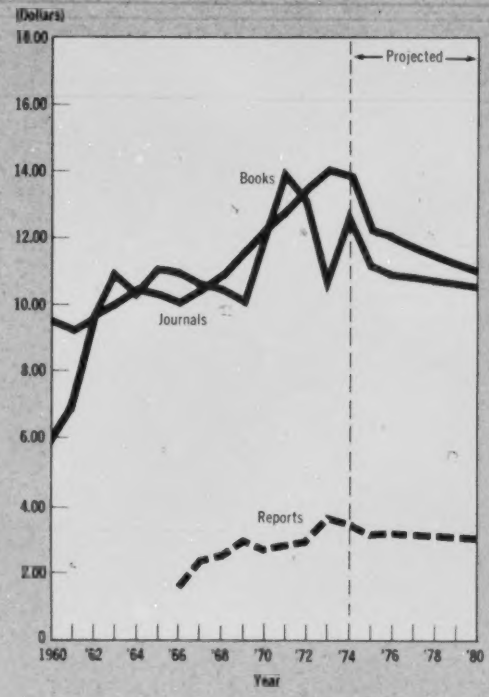
Price of journals, books and reports is given in current and constant dollars in Figures 58 and 59 respectively. There is not a dramatic difference in the general trend of prices (particularly since 1962) between the journal and book forms of literature. In current dollars, journal subscription prices increased from $5.30 in 1960 to $20.00 in 1974 and books increased from $8.50 to $18.40. Data were not available for reports prior to 1966. From 1966 to 1974, when data were available for all forms of literature, the prices in constant dollars rose 39, 14, and 123 percent respectively for journals, books and reports. This represents an average growth rate of 4.2 percent for journals, 1.7 percent for books, and 10.5 percent for reports. Forecast for all three forms of literature is for price to decrease slightly in constant dollars over the next 5 years.

Figure 58
Price per copy by medium, in current dollars (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences
R. R. Bowker Company (Books: 1960-1974)

Figure 59
Price per copy by medium in constant dollars (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

Chapter 4

Growth of Scientific and Technical Library and Secondary Service Activities in the United States

Chapter 4

Growth of Scientific and Technical Library and Secondary Service Activities in the United States

Since scientific and technical (S&T) literature is usually not used at the time it is published and distributed, libraries and secondary services play an important part in transfer of information. The growth of these enterprises is, therefore, an important indicator in S&T communication. This section discusses the role of libraries and abstracting and indexing (A&I) services in the acquisition, storage, organization and control, identification, location and accessing of S&T literature. Applicable data in these areas are, unfortunately, scarce, but some trends can be identified. It is shown that technological development, particularly in the computer area, have begun to result in change in the operations of libraries and secondary services and can be expected to have a significant impact in the future.

HIGHLIGHTS

- Scientific and technical library expenditures increased dramatically between 1960 and 1974. Material expenditures increased 254 percent in constant dollars and other expenditures, again in constant dollars, increased 193 percent. Growth, however, peaked around 1972 and constant dollar expenditures are not projected to increase further in the period to 1980. Expenditures per scientist should likewise remain constant over the near future. The combination of these factors with continued increases in the cost and volume of scientific materials will require adaptive measures on the part of libraries. Such measures already involve increased use of new technology and various networking arrangements.
- The total number of items processed by U.S. members and affiliates of the National Federation of Abstracting and Indexing Services (NFAIS) increased 145 percent between 1960 and 1974 and is projected to increase an additional 33 percent by 1980. This reflects both increased production of world literature as well as increased coverage by the A&I services. The accessibility of A&I products has been increased substantially by expanded use of computer search systems for bibliographic data bases.
- Both libraries and secondary services play important roles in the identification and accessing of the S&T literature. In an author's survey conducted as part of this study, libraries and A&I services accounted for over 20 percent of the article identifications made. Nearly half of all articles used were from library subscription copies.

DISCUSSION

Several of the functions included in S&T communication involve intermediaries between authors and users of literature. Chief among these intermediaries are libraries and secondary services.

Libraries acquire and store published materials, organize them for use, and facilitate their availability. Their collections cover the

range of S&T literature, and are organized so that materials can be retrieved by a wide community of users. A unique function of libraries is their role as a permanent archive of scientific achievement. Several types of libraries contribute to the communication of scientific and technical information, (STI), including academic, public and special libraries. Overlapping these classifications, research and Federal libraries often serve as sources of STI.

Secondary services provide access to the literature through such means as A&I publications; machine-readable bibliographic data bases; national and other bibliographies; and review publications. Among the secondary literature sources, A&I services play an important role in providing the intellectual access and organization of the scientific literature which allows it to be accessed effectively by scientists and engineers engaged in research activities. While concentrating primarily on the journal literature, A&I services treat all literature to some extent, and provide scientists with current awareness of materials relevant to their fields of interest as well as guides for retrospective search of the world's literature. The products of A&I services include both printed indexes and machine-readable bibliographic data bases.

As mentioned, libraries are usually classified as academic, public or special according to the primary clientele they serve. In general, academic and special libraries play a more significant role in the dissemination of STI than do public libraries. Two groups of libraries which fit into more than one of the three classifications and serve as important sources of STI are research libraries and Federal libraries.

Research libraries, as represented by the membership of the Association of Research Libraries (ARL) in the discussions which follow, build and maintain extensive collections of research literature. They preserve the record of the achievements of S&T as reflected in the published literature. It is these libraries that assume the major responsibility for ensuring that research materials are available to scientists and other scholars when they are needed. The Federal libraries include a number of specialized libraries. Of the 2,313 Federal libraries identified in 1972, 43 percent were classified as special or technical. Among these were the three national libraries including the Library of Congress, the National Library of Medicine, and the National Agricultural Library. Each of these libraries provides extensive informational services to both individual scientists and to other libraries.

Closely related to libraries, information centers also play a role in the S&T communication process. Like special libraries, information centers are characterized by limited subject areas. In addition, the term information center implies a greater depth of analysis and control and frequently more advanced services such as evaluation and synthesis of material. Information centers may also include raw data among the materials held.

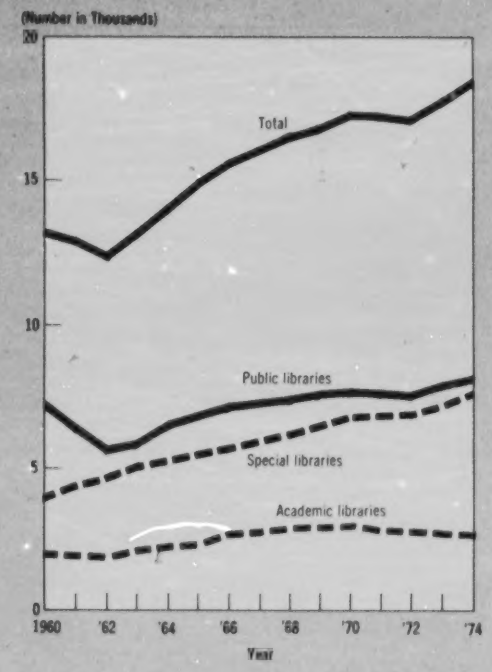
Unfortunately, there is little information that expresses library resources in terms of STI services and products. Trends are given below, in the absence of STI data, for number of libraries, total library expenditures, and material expenditures. These data are given for academic libraries, special libraries, public libraries, Federal S&T libraries, and a sample of 58 ARL. Trends in the number of libraries are displayed in Figure 60. As shown, the total number of libraries has increased 30 percent in the last 10-year period, from 14,000 in 1964 to over 18,000 in 1974. Within this period, the number of academic libraries and public libraries has increased 24 percent each, and special libraries 40 percent. In 1974, public libraries made up about 44 percent of the total population, special libraries 41 percent, and academic libraries 15 percent.

The number of academic ARL libraries has increased from 74 in 1964 to 82 in 1974, an 11 percent increase.[1] Growth in Federal S&T libraries has been significant, with the number of such libraries almost doubling between 1965 and 1972. In 1972, there were 995 Federal S&T libraries.

Total expenditures for S&T library activities is computed by estimating the proportion of total expenditures which are devoted to science and technology. The principal factors affecting these costs are the percentages of S&T material expenditures and S&T service expenditures (circulation, reference, interlibrary loan). Precise data are not available for all libraries but information from several individual libraries suggests that about 50 percent of the academic library expenditures

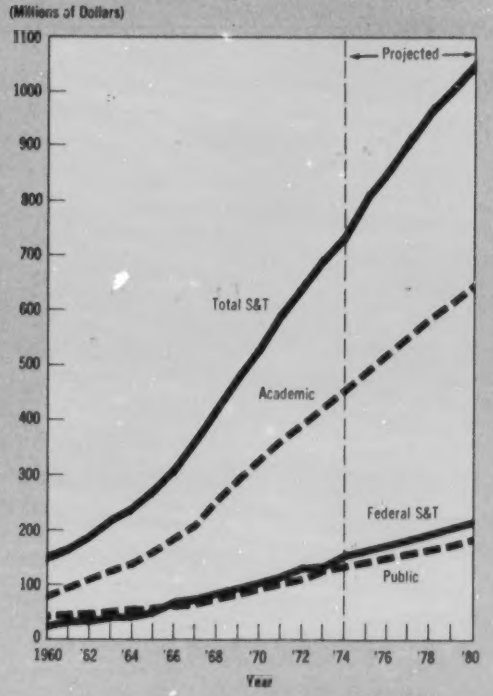
[1] ARL membership also includes a number of non-university libraries. In 1975, there were 88 academic members and 11 others for a total of 99.

Figure 60
Number of U.S. academic, special and public libraries (1960-1974)



SOURCE: The Bowker Annual of Library and Book Trade Information, R. R. Bowker Company, 1961-1975
Association of Research Libraries, American Library Statistics, 1960-1972

Figure 61
U.S. S&T library expenditures in current dollars (1960-1980)



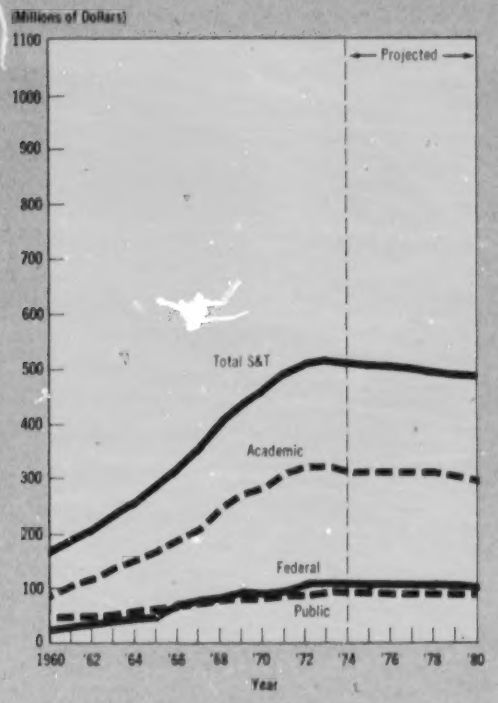
SOURCE: King Research, Inc., Center for Quantitative Sciences

and 10 percent of the public library expenditures are devoted to science and technology. Federal S&T library expenditures are included entirely in the estimates below. Expenditures for non-Federal special libraries are not known so that these expenditures are not included. The total expenditures are computed by applying the estimated proportions and summing the resultant academic, public, and Federal S&T library expenditures. Figures 61 and 62 show total S&T library expenditures through 1980 in current and constant dollars. In 1974, total expenditures were over $700 million. In constant dollars, expenditures for each library type and for all STI library activity appear to have peaked in the 1972-1973 period and to continue on a level trend through 1980.

One statistical indicator of library expenditures in S&T is the library expenditures per scientist (including science and engineering graduate students). Results of this computation are given in constant dollars in Figure 63. The average expenditure per scientist in constant dollars rose from $110 in 1960 to a peak of $175 in 1972 and then decreased to $164 in 1974. The expenditure (in constant dollars) per scientist is expected to remain at about the 1974 level through 1980.

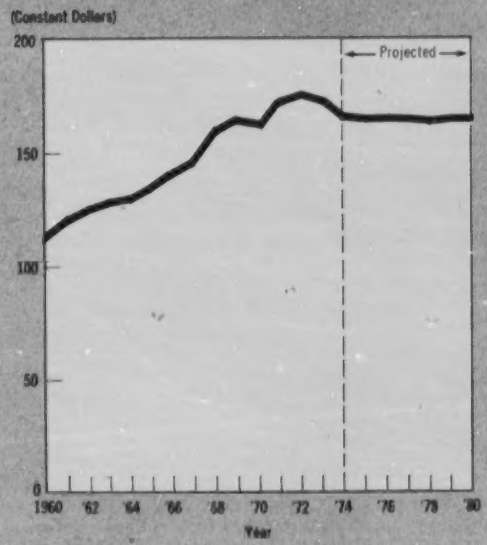
Library material expenditures showed a large increase from 1960 to 1974. These expenditures for S&T activities were estimated in the same manner as total expenditures, again omitting non-Federal special libraries because of lack of data. Results are shown in Figures 64 and 65 in current and constant dollars. In constant dollars, the estimated S&T material expenditures increased over 250 percent between 1960 and 1974, going from $41 million to $145 million.

Figure 62
U.S. S&T library expenditures in constant dollars (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 63
S&T library expenditures per scientist or engineer (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

This increase also represented a slight rise in the proportion of total expenditures spent on materials.

Increases in material expenditures were greatest for the academic libraries, where, in constant dollar terms, they amounted to 279 percent between 1960 and 1974. This could be a response to increases in the number of scientists served, the volume of available materials, and the price of available materials. In terms of the actual number of volumes added, academic libraries acquired 9.4 million volumes in 1960 and 25.0 million in 1974, a 166 percent increase. Growth was greatest prior to 1970. The acquisition role in ARL libraries has followed a similar pattern.

Subtracting library material expenditures from total expenditures, a figure is derived which can be identified as service costs. These costs, which primarily reflect salaries, are shown in Figure 66 in current and constant dollars. An equal distribution is assumed in apportioning these costs to the three functions with which libraries are involved (acquisition and storage, organization and control, and identification and access). Thus one-third of library service costs are attributed to the purchase and maintenance of a collection, the creation of catalogs and other identification aids as well as provision of reference, circulation, and other services.

Abstracting and indexing services play a role in organization and control of the literature and also in its identification and accessing by the user. As with libraries, data on the S&T components of A&I services, are scarce. The best source of available data is NFAIS.

The NFAIS has estimated that there were approximately 2,100 A&I services worldwide in 1974. These range considerably in size. NFAIS itself includes a number of the largest noncommercial A&I services, and had a total of 29 members in 1974 which includes 28 U.S. and one foreign affiliate. These organizations make up a substantial portion of U.S. A&I operations.

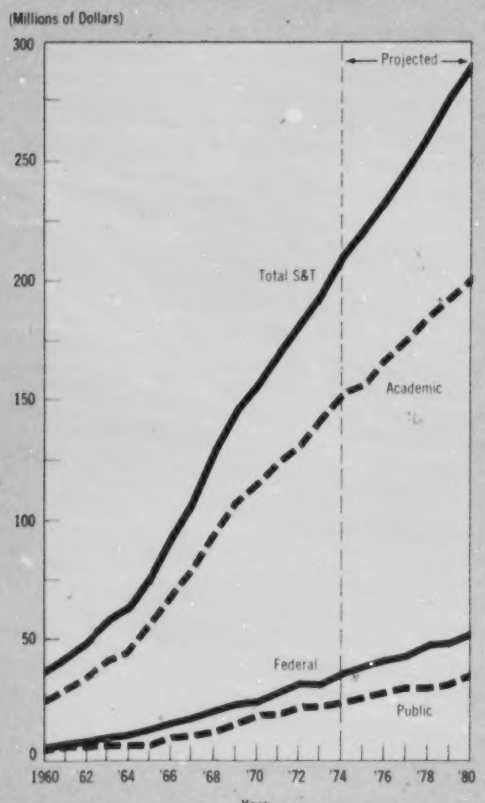
Statistics on the number of items processed by U.S. NFAIS members are displayed in Figure 67. Growth was from 588,000 items processed in 1960 to 1.4 million items processed in 1974, an increase of 145 percent. These figures include overlap, that is, duplicate coverage of a single item by two or more organizations. In addition, the amount of overlap can vary from year to year. For these reasons, the number of items processed cannot be considered representative of the size of the literature.

Another indicator of the volume of abstracting and indexing in the U.S. is the number of citations included in the data bases provided by two major commercial search services (Lockheed's DIALOG and the SDC Search Service).

These organizations provide on-line computer access to the world's principal data bases, and their coverage and usage have increased rapidly in recent years. Currently (1976), the two systems include a total of 46 data bases containing over 13 million citations. These data bases are increasing at an annual rate of over 3 million citations per year.

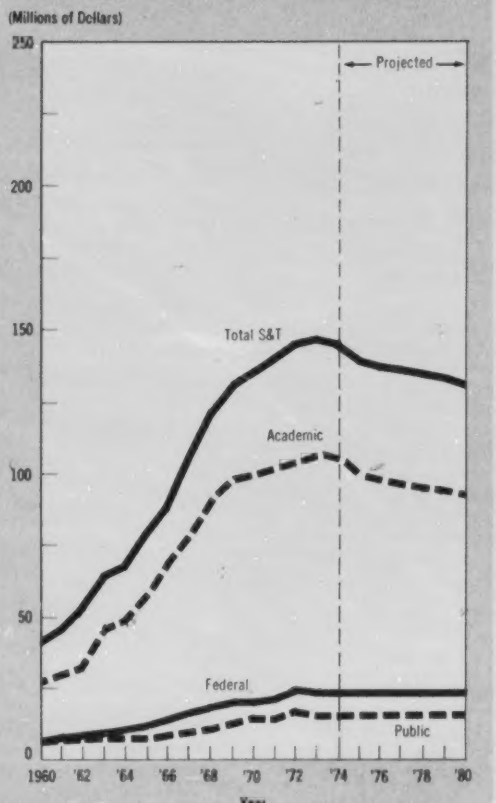
Estimated costs incurred by the A&I services in treating the S&T literature are shown in Figure 68 and 69 in current and constant dollars respectively. Also shown are library costs associated with organization and control of the literature, as derived previously. Together these two costs make up the total estimated cost of the organization and control function.

Figure 64
U.S. S&T library material expenditures in current dollars (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 65
U.S. S&T library material expenditures in constant dollars (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

Both libraries and secondary services play important roles in the identification and accessing functions. Abstracting and indexing publications, bibliographic data bases, and library catalogs all describe the S&T literature in such a way as to facilitate the identification of relevant material by a potential user. Libraries serve as a major storehouse of, and thus, access point to literature collections.

The author survey part of this study provides information about the ways in which scientists identified and gained access to articles which they cited. These data, reflecting both the use of libraries and secondary services and other methods, are presented as a part of the discussion of scientists' information activities in Chapter 5.

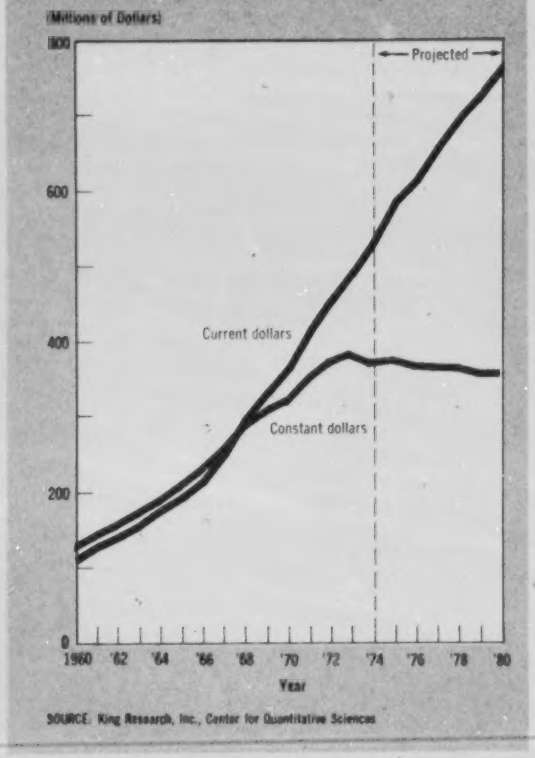
The use of A&I services, including abstracting publications and retrospective and current awareness searches of machine-readable bibliographic data bases, accounted for about 18 percent of the total uses reported by survey respondents. This percent varied significantly among scientific fields, the most substantial being in the Physical Sciences and Engineering. The smallest percentages were observed in Mathematics and the Environmental Sciences.

From the survey, the use of A&I services appeared to be declining slightly in relation to other identification methods. Other sources, however, suggest that the use of computerized literature searches, particularly via on-line systems, is expanding rapidly. These, then, should play an important role in identification in the future.

Figure 70 is a graph showing an estimate of the number of interactive bibliographic searches made in the U.S. The increase between 1971 and 1974 as shown is nearly 160 percent and even more rapid growth is anticipated in the future. Other sources suggest the growth in the use of commercial services may be as much as 50 to 100 percent each year.

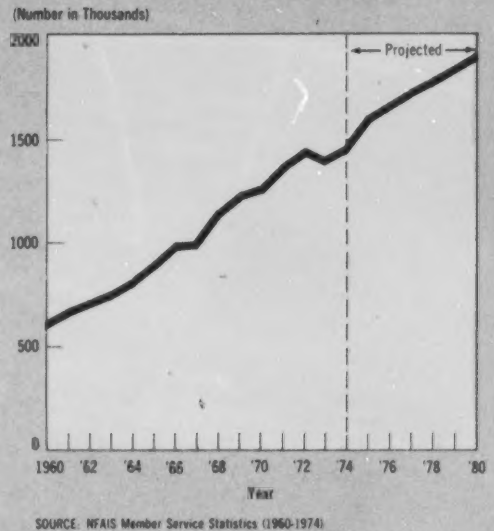
Direct identification of journal articles through library subscriptions was reported in

Figure 66
U.S. S&T library service expenditures (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 67
Number of items processed by U.S. National Federation Of Abstracting And Indexing Services members (1960-1980)



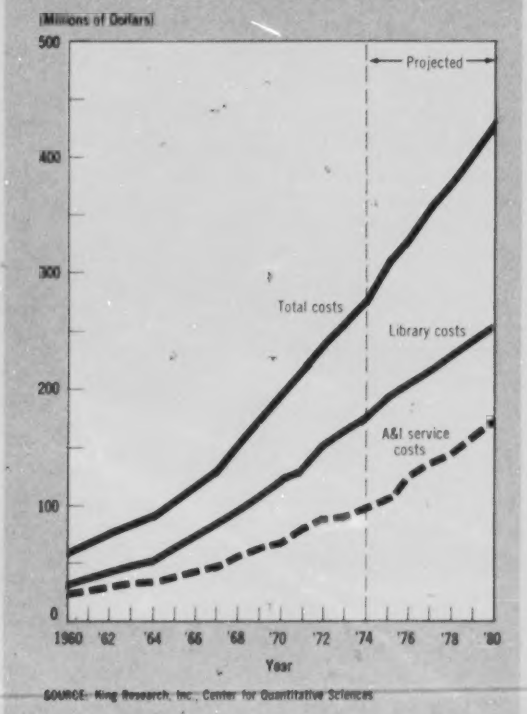
SOURCE: NFAIS Member Service Statistics (1960-1974)
King Research, Inc., Center for Quantitative Sciences (1975-1980)

the author survey as making up about 18 percent of the total direct identifications (Figure 73). Again, the percentage varies among the fields of science, with the scientists in the Social Sciences, Computer Science and Engineering utilizing library subscriptions heavily (69 and 41 percent of all direct identifications respectively) and those in Mathematics and the Physical Sciences making less use of library subscriptions (14 and 21 percent of all direct identifications respectively.)

Access sources considered in the author survey included authors, colleagues, journal publishers, and libraries. A substantial proportion of all accesses, nearly half, were made through library subscription copies. (See Figure 76). In 1974, this also represented about 60 percent of all accesses through subscriptions. Comparing this with the percent of journal subscriptions which go to libraries (40 percent in 1974), apparently proportionately more use is made of library subscription copies than individual subscription copies, as one might expect. Libraries are used particularly heavily for access to the older literature.

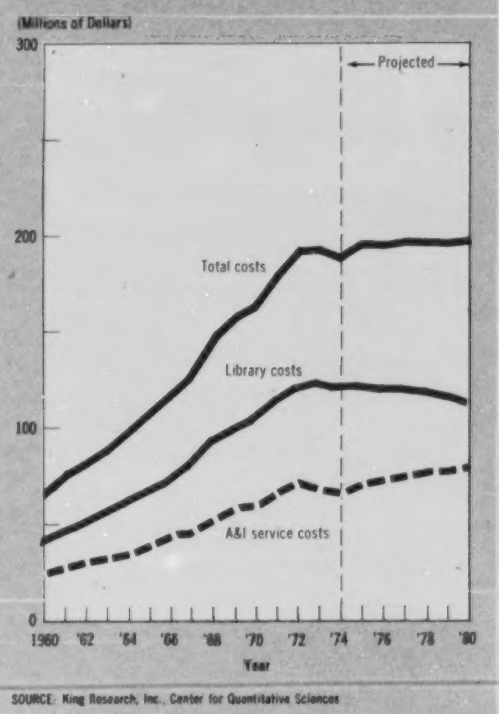
Access through library subscription copies may include both use of a journal actually held by the scientists' primary library, or the acquisition of the article from another library by interlibrary loan (ILL). The volume of ILL throughout the U.S. is substantial, and the development of the ILL system has been fostered by recent developments in library cooperation and networking. A 1972 estimate of the total number of ILL made (both periodicals and other materials) was slightly over four million transactions, and observation of current trends in individual libraries and library systems suggests that this figure will have doubled by 1980.

Figure 68
Estimated cost of organization and control of the S&T literature in current dollars (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

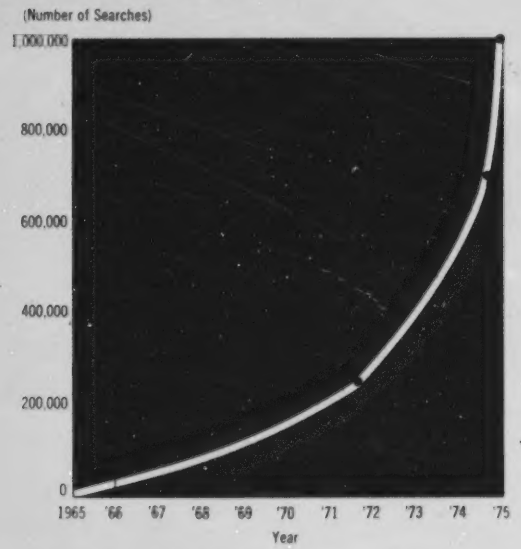
Figure 69
Estimated cost of organization and control of the S&T literature in constant dollars (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

Figure 70

Growth of interactive bibliographic searching in the U.S. (1966-1975)



SOURCE: NEWSIDIC No. 14 (October 1975)

Chapter 5

Growth in the Information Activities of Scientists and Engineers

Chapter 5

Growth in the Information Activities of Scientists and Engineers

As indicated previously, scientists and engineers make the greatest contribution to resources expended in scientific and technical (S&T) communication. Therefore, indicators concerning their numbers and their contribution to communication resource expenditures are essential for understanding trends in communication indicators.

This section discusses the activities surrounding the preparation and recording of scientific and technical information (STI), and also the activities associated with identification of and access to information transmitted through formal journal channels. Data based on citation analysis are also presented which indirectly measures the assimilation and use of information presented through these channels. Sources drawn upon are an author survey and other research relevant to statistical indicators of information transfer.

HIGHLIGHTS

- Costs associated with scientists and engineers are the largest contribution by all participants to total communication resource expenditures. These costs include composition, recording, and assimilation of information, which collectively amounted to $1.3 billion in 1960 and $5.4 billion in 1974. This reflects an average annual growth rate in costs of 10.6 percent. Composition and recording costs increased from $340 million in 1960 to $1.8 billion in 1974, an average annual increase of 12.9 percent. The growth rate for assimilation was slightly lower at 9.7 percent, ranging from $980 million in 1960 to $3.6 billion in 1974. In all, costs associated with scientists' and engineers' activities accounted for 65.5 percent of total communication resource expenditures in 1960 and 63.7 percent in 1974.
- A significant component of the overall transfer of STI is the total resource devoted to the use, or assimilation of the published literature. By estimating this by the amount of time spent reading the literature, journals were found to account for the largest proportion of resources devoted to assimilation or use of the literature. The total cost of labor time devoted to reading literature is estimated at $4.0 billion in 1975 and is projected to rise 59 percent between 1975 and 1980.
- Scientists and engineers generally rely more upon examination of journal subscription issues or use of references listed in other articles, books, or reports, than upon formal indexing or abstracting tools for initially identifying journal articles which they cite in their own articles. Significant differences appear to exist among fields of science in methods used by authors to identify their cited articles.
- Journal articles used for citation were obtained most frequently through libraries (50.8 percent), with personal journal subscriptions (20.6 percent), reprints (16.1 percent) and colleagues (12.5 percent), following in that order.

DISCUSSION

In the information transfer spiral, scientists and engineers initiate activity by authorship of documents. They also serve as the recipients and users of published materials, after publishers and libraries have played their roles. Use of the literature in turn leads to

further research and generation of information, and again to authorship.

There were 1.2 million scientists and engineers in the U.S. in 1960 and 2.0 million in 1975; an overall increase of 75 percent or an average annual increase of 3.8 percent over this period. Growth is expected to continue at about 2.7 percent per year to 1980. These data are based on an analysis of secondary sources generated by the National Science Foundation, the U.S. Department of Labor, and the U.S. Census Bureau. Included are scientists and engineers in each of the nine NSF fields of science—Physical Sciences, Mathematics, Computer Science and Engineering, Environmental Sciences, Engineering, Life Sciences, Psychology, Social Sciences, and Other Sciences.

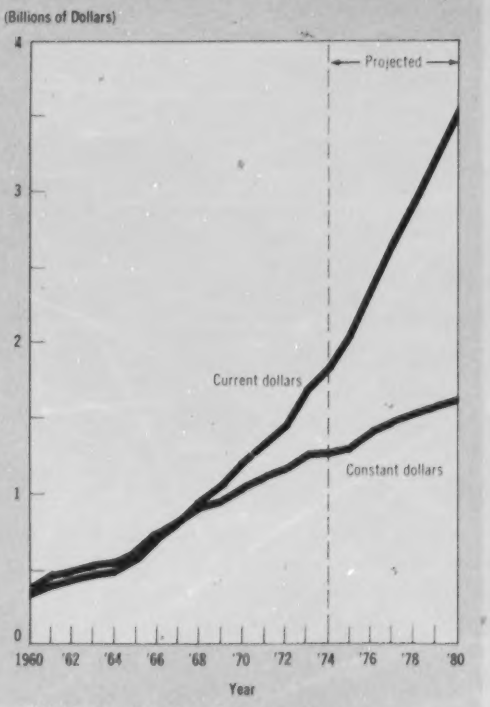
In 1960 there were 406,000 research and development (R&D) scientists in the U.S., and in 1974 there were 623,000; an overall growth of 53 percent or an average annual increase of 3.1 percent. Growth is only expected to continue past this point, at an average annual increase of 1 percent. R&D scientists as a percent of total scientists employed peaked between 1964 and 1967 at almost 38 percent. Decreasing percentages were then observed through 1974, and are expected to continue to decrease through 1980. However, these proportions, as reported by NSF, are based on "natural" scientists and engineers (thus excluding social scientists at least) and full-time equivalents. In addition, State and local government R&D employment is not included. Whether or not the decrease would remain with these factors represented, remains unanswered.

As shown previously, the activities of scientists and engineers account for a major portion, about 65 percent, of total S&T communication resource expenditures. Included in these expenditures are the costs of authorship and of assimilation and use of the literature. Available data on each of these areas are discussed in the remainder of this chapter as are data on the methods used by scientists in identifying and accessing the literature.

There is little information in the literature concerning the processes involved in composition and recording of information. Some data, however, are provided by a study performed[1] for the National Science Foundation concerning the journal literature. This study provides some evidence concerning the activities involved in preparing journal articles, the labor time required in these activities, and hence, the costs involved. The composition and recording functions are extremely important to the journal system since quality of articles is largely established in these functions. Furthermore, the costs involved in these processes are large and likely to exceed the costs involved in reproduction and initial distribution of articles.

Based on the study above, one can estimate the cost of composition and recording for the journal literature. This includes those activities performed by authors and their support staff, reviewers and editors. Making some gross assumptions, similar estimates are made of the cost of composition and recording of books, reports, dissertations, and patents. The combined results of these calculations are shown in Figure 71. As shown, composition and recording costs increased substantially in

Figure 71
Cost of composition and recording in current and constant dollars (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

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the 1960 to 1974 period, going from over $300 million in 1960 to over $1.84 billion in 1974. In constant dollar terms, this is an overall increase of 232 percent, equivalent to an average annual increase of about 8.9 percent. Costs are expected to continue increasing at about this same rate over the next 5 years. The reasons these costs have gone up so much and will continue to do so is that they reflect increases both in the number of items produced and in salaries.

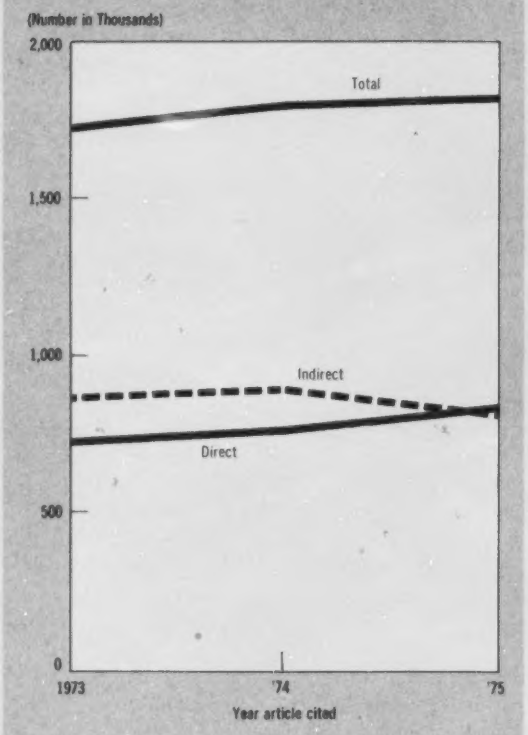
A survey of journal article authors was conducted as part of this study. Of particular interest are the responses authors gave concerning other journal articles which they cited in their own articles. Author responses on (1) how they became aware of articles, and (2) how they obtained physical access to these articles, should be useful as statistical indicators of the use of the formal S&T journal literature.

Authors of journal articles published between 1968 and 1975 were contacted by mail. Because of probable recall problems associated with older articles, only articles published in 1973, 1974, and 1975 are included. The sample size for this study was 2,173 authors and the number of used responses was 956. Thus, the response rate was 44 percent.

Methods of identification of the journal literature can be classified as direct or indirect. Indirect identification implies that the user first learned of an article through a formal or informal reference to it, such as an abstract in a Selective Dissemination of Information (SDI) service. Direct identification comes, not through a reference, but from direct contact with the actual article such as with one's journal subscription or as when a relevant article is discovered serendipitously while browsing in the library. Figure 72 shows the total number of journal articles identified by direct and indirect methods for 1973, 1974, and 1975.

Subdividing the methods of article identification further, Figures 73 and 74 show, respectively, the major direct and indirect activities. Direct identification methods displayed in Figure 74 include individual subscriptions, library subscriptions and reprints and preprints. Direct identification accounted for about 40 percent of all journal article identifications overall. Within this 40 percent, individual subscription copies were most often mentioned as the method of access used.

Figure 72
Article identification methods



SOURCE: King Research, Inc., Center for Quantitative Sciences, Author Survey (1973, 1974, 1975 Selected Data)

Indirect identification procedures include reference to an article by a colleague or coworker; reference made by another article, book, or report; use of printed indexes or catalogs; use of a computerized literature search; and use of a current awareness or SDI system. Since the last three methods were employed infrequently, they are grouped together in Figure 74.

As shown, a reference in an article, book, or report was the indirect identification method mentioned most frequently by journal article authors. References by colleagues also played a significant role. A slight decrease in the use of abstracts and indexes was observed. This result represents mostly the use of printed indexes and catalogs, with a small number of SDI searches made over the years and a small but increasing number of computerized literature searches.

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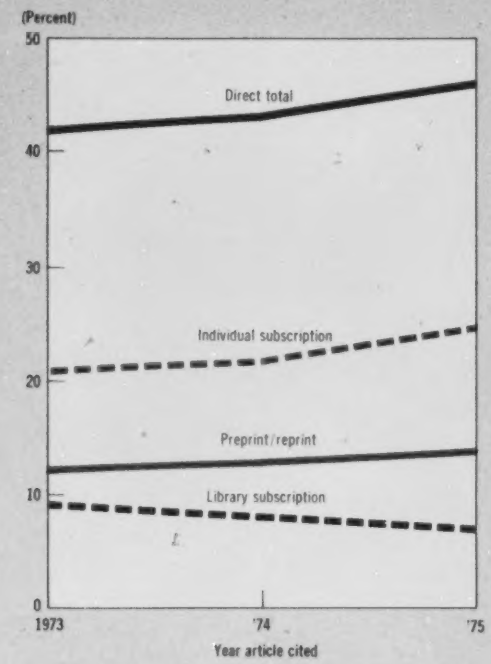
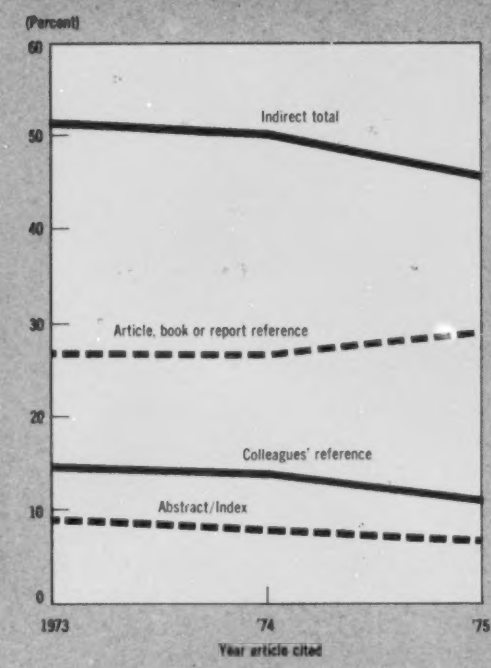
Figure 73
Percent of total article identifications made by direct article identification methods



SOURCE: King Research, Inc., Center for Quantitative Sciences, Author Survey (1973, 1974, 1975 Selected Data)

Figure 74
Percent of total article identifications made by indirect article identification methods



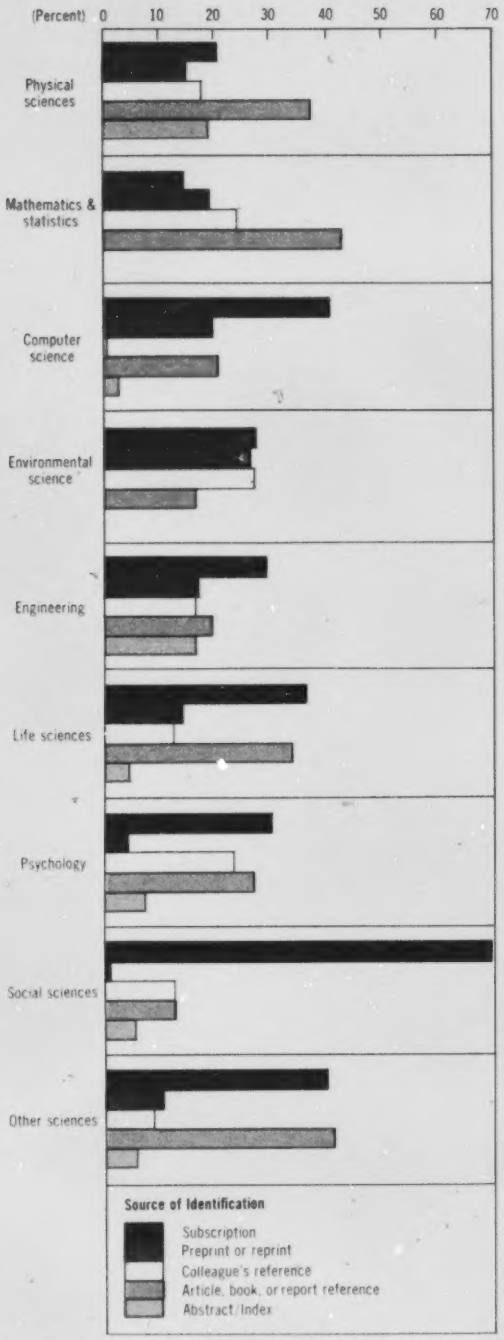
SOURCE: King Research, Inc., Center for Quantitative Sciences, Author Survey (1973, 1974, 1975 Selected Data)

Considering methods of access to the literature, one can distinguish both between the various sources of access—library, publisher, author, and colleague—and also between subscription and nonsubscription forms of access. The breakdown among sources of access is shown in Figure 76. Libraries are consistently the most often used access source. Access directly from authors (i.e., through author reprints or preprints) and

Figure 75 displays aggregated 1973, 1974, and 1975 author survey data by field of science. There appear to be significant differences among the various fields of science in the way cited articles are identified. Social Sciences show the greatest disparity between use of subscriptions (say, by browsing through one's own or a library's copy) and identification through receiving a reprint or preprint or through other sources. Physical Sciences, Mathematics, Life Sciences, and Other Sciences show the strongest use of references in other articles, books, or reports. Reliance upon the identification of an article to be cited by means of formal indexing or abstracting tools is low in all fields.

Considering methods of access to the literature, one can distinguish both between the various sources of access—library, publisher, author, and colleague—and also between subscription and nonsubscription forms of access. The breakdown among sources of access is shown in Figure 76. Libraries are consistently the most often used access source. Access directly from authors (i.e., through author reprints or preprints) and access through colleagues have increased slightly. The volume of accesses by means of individual user subscriptions and the purchase of reprints from publishers, has

Figure 75
Article identification by field of science

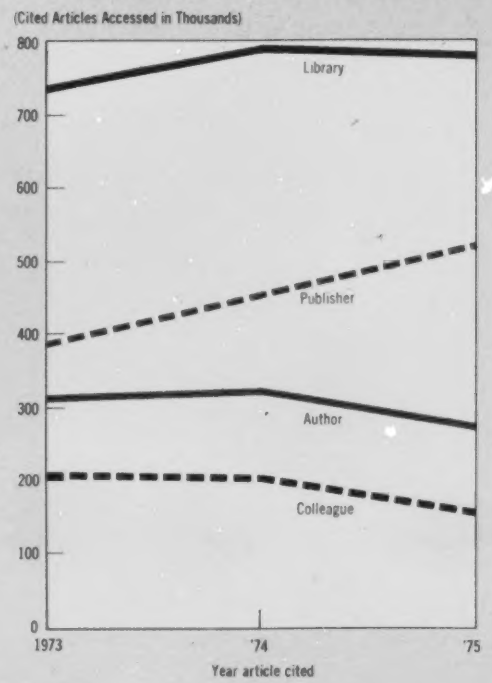


SOURCE: King Research, Inc., Center for Quantitative Sciences

grown substantially in recent years. It appears that the use of subscriptions for obtaining access to cited articles has risen nearly proporational to the rise in the total number of articles cited. At the same time, the access through nonsubscription forms (reprints, preprints, etc.) has remained fairly constant.

In order to estimate total resources expended by scientists and engineers on reading the literature, several studies summarized in the SATCOM report[5] were used. Based on these, overall averages of reading time per scientist were assumed. The average time spent by scientists is assumed to be 83.2 hours spent per year reading journals, 41.6 hours per year reading S&T books, and 2 hours reading each report ordered from the National Technical Information Service and the U.S. Government Printing Office. The resulting estimates of the steadily increasing cost of assimilation and use of the S&T literature are shown in Figure 77.

Figure 76
Relative use of sources of access to cited articles, by year of citing article



SOURCE: King Research, Inc., Center for Quantitative Sciences, Author Survey (1973, 1974, 1975 Selected Data)

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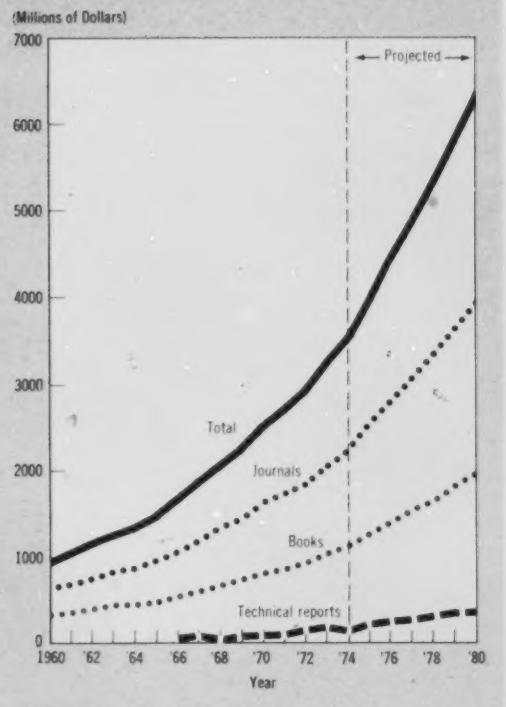
Figure 77

Estimated total cost of assimilation of S&T literature (1960-1980)



SOURCE: King Research, Inc., Center for Quantitative Sciences

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   Annex Part I: *A Baseline Study of Current Journal Publishing Practices in the Life Sciences.*

   Annex Part II: *A Review of Relevant Technology to the Publication of Scientific and Technical Journals.*

   Annex Part III: *The Design of Four Systems Configurations for Publishing Scientific and Technical Journals.*

   Annex Part IV: *Survey of Authors, Reviewers, and Subscribers to Journals in the Life Sciences.*

   Annex Part V: *Economic Analysis of Journal Publishing in the Life Sciences.*

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Appendix A

Indicators

Table 2. Total S&T communication resource expenditures: 1960-1980

[Millions of dollars]

Year	Expenditures (Current $)	Expenditures (Constant $)*
1960	2,013	2,292
1961	2,264	2,545
1962	2,490	2,768
1963	2,737	3,003
1964	2,925	3,160
1965	3,279	3,478
1966	3,712	3,831
1967	4,212	4,212
1968	4,673	4,492
1969	5,267	4,831
1970	5,846	5,083
1971	6,402	5,326
1972	6,939	5,584
1973	7,751	5,906
1974	8,525	5,893
Projections		
1975	9,431	5,965
1976	10,504	6,226
1977	11,595	6,437
1978	12,684	6,588
1979	13,889	6,780
1980	15,128	6,941

* GNP Implicit Price Deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 3. Total S&T communication resource expenditures, gross national product and research and development funds in current dollars: 1960-1980

[Billions of dollars]

Year	GNP[1]	R&D Funds[2]	Communication Expenditures[3]
1960	503.7	13.551	2.013
1961	520.1	14.346	2.264
1962	560.3	15.426	2.490
1963	590.5	17.093	2.737
1964	632.4	18.894	2.939
1965	684.9	20.091	3.279
1966	749.9	21.894	3.712
1967	793.9	23.205	4.212
1968	864.2	24.669	4.673
1969	930.3	25.686	5.267
1970	977.1	26.047	5.846
1971	1,054.9	26.745	6.402
1972	1,158.0	28.402	6.939
1973	1,294.9	30.427	7.751
1974	1,396.7	32.045	8.525
Projections			
1975	1,475.2	[3]34.345	9.431
1976	1,680.5	36.469	10.504
1977	1,878.3	38.867	11.595
1978	2,065.2	41.605	12.684
1979	2,273.6	44.761	13.884
1980	2,499.1	48.432	15.128

SOURCES:
[1] *Economic Report of the President*, February 1975 GNP, 1960-1974 National Planning Association, 1975-1980.
[2] National Science Foundation, *National Patterns of R&D Resources*, 1953-1975 (NSF 75-307)
[3] King Research, Inc., Center for Quantitative Sciences.

Table 4. Ratio of S&T communication resource expenditures to GNP: 1960-1980

Year	Expenditures GNP (10^{-3})	Year	Expenditures/ GNP
1960	4.0	1971	6.1
1961	4.4	1972	6.0
1962	4.4	1973	6.0
1963	4.6	1974	6.1
1964	4.7	**Projections**	
1965	4.8	1975	6.4
1966	5.0	1976	6.3
1967	5.3	1977	6.2
1968	5.4	1978	6.1
1969	5.7	1979	6.1
1970	6.0	1980	6.1

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 5. Ratio of S&T communication resource expenditures to research and development funding: 1960-1980

Year	Expenditures/ Research and Development	Year	Expenditures/ Research and Development
1960	.15	1971	.24
1961	.16	1972	.24
1962	.16	1973	.25
1963	.16	1974	.27
1964	.15	**Projections**	
1965	.16	1975	.27
1966	.17	1976	.29
1967	.18	1977	.30
1968	.19	1978	.30
1969	.20	1979	.31
1970	.22	1980	.31

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 6. Estimated number of scientists and engineers: 1960-1980

[Thousands]

Year	Scientists and Engineers	Year	Scientists and Engineers
1960	1,159	1971	1,834
1961	1,210	1972	1,871
1962	1,272	1973	1,923
1963	1,346	1974	1,973
1964	1,396	**Projections**	
1965	1,442	1975	2,026
1966	1,501	1976	2,081
1967	1,578	1977	2,138
1968	1,649	1978	2,195
1969	1,725	1979	2,255
1970	1,797	1980	2,314

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 7. S&T communication resource expenditure per scientist or engineer in current and constant dollars: 1960-1980

[Thousands of dollars]

Year	Expenditures/ Scientists and Engineers (Current $)	Expenditures/ Scientists and Engineers (Constant $)*
1960	1.74	1.98
1961	1.87	2.10
1962	1.96	2.18
1963	2.03	2.23
1964	2.10	2.27
1965	2.27	2.41
1966	2.47	2.55
1967	2.67	2.67
1968	2.83	2.73
1969	3.05	2.80
1970	3.25	2.83
1971	3.49	2.90
1972	3.71	2.99
1973	4.03	3.07
1974	4.32	2.99
Projections		
1975	4.65	2.94
1976	5.05	2.99
1977	5.42	3.01
1978	5.78	3.00
1979	6.16	3.01
1980	6.54	3.00

* GNP Implicit Price Deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 8. Ratio of S&T communication resource expenditure per scientist to median scientists' salaries: 1960-1980

Year	Expenditure per Scientist/Average Scientists' Salaries
1960	.185
1961	.193
1962	.196
1963	.197
1964	.198
1965	.199
1966	.204
1967	.208
1968	.211
1969	.213
1970	.215
1971	.219
1972	.223
1973	.225
1974	.224
Projections	
1975	.224
1976	.225
1977	.226
1978	.227
1979	.227
1980	.229

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 9. Total S&T communication resource expenditures by medium in current dollars: 1960-1980

[Millions of dollars]

Year	Books	Journals	Reports	Other Literature	Total
1960	571	1,277	22	141	2,013
1961	631	1,461	26	143	2,264
1962	688	1,616	28	157	2,490
1963	752	1,788	32	165	2,737
1964	817	1,897	34	177	2,925
1965	901	2,105	57	214	3,279
1966	1,004	2,384	105	219	3,712
1967	1,116	2,724	135	235	4,212
1968	1,235	3,042	133	264	4,673
1969	1,376	3,410	175	306	5,267
1970	1,519	3,789	205	334	5,846
1971	1,660	4,145	239	360	6,402
1972	1,777	4,491	305	365	6,939
1973	1,953	5,034	364	400	7,751
1974	2,144	5,559	388	433	8,525
		Projections			
1975	2,352	6,114	471	494	9,431
1976	2,570	6,852	539	543	10,504
1977	2,807	7,572	619	597	11,595
1978	3,039	8,304	693	648	12,684
1979	3,288	9,108	781	707	13,889
1980	3,538	9,943	877	770	15,128

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 10. Total S&T communication resource expenditures by medium in constant dollars: 1960-1980

[Millions of constant 1967* dollars]

Year	Books	Journals	Reports	Other Literature	Total
1960	650	1,454	25	161	2,292
1961	709	1,642	29	161	2,545
1962	765	1,796	31	174	2,768
1963	825	1,962	35	181	3,003
1964	883	2,049	52	191	3,175
1965	956	2,233	60	227	3,478
1966	1,036	2,460	108	226	3,831
1967	1,116	2,724	135	235	4,212
1968	1,187	2,925	128	254	4,493
1969	1,262	3,128	161	281	4,831
1970	1,321	3,294	178	290	5,083
1971	1,381	3,448	199	299	5,326
1972	1,430	3,614	245	294	5,584
1973	1,488	3,836	277	305	5,906
1974	1,482	3,843	268	299	5,893
		Projections			
1975	1,488	3,867	298	312	5,966
1976	1,523	4,061	319	322	6,226
1977	1,558	4,204	344	331	6,437
1978	1,578	4,313	360	337	6,588
1979	1,605	4,446	381	345	6,780
1980	1,623	4,562	402	353	6,941

* GNP Implicit Price Deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 11. Total S&T communication resource expenditures by participants in current dollars: 1960-1980

[Millions of dollars]

Year	Scientist (Author)	Publisher	Library	Scientist (User)	Total
1960	337	154	540	982	2,013
1961	403	183	622	1,056	2,264
1962	424	245	676	1,145	2,490
1963	482	267	740	1,248	2,737
1964	503	295	796	1,331	2,939
1965	597	320	883	1,479	3,279
1966	711	356	979	1,666	3,712
1967	834	416	1,094	1,868	4,212
1968	939	474	1,233	2,026	4,673
1969	1,065	548	1,376	2,278	5,267
1970	1,202	616	1,516	2,512	5,846
1971	1,342	684	1,669	2,709	6,402
1972	1,464	762	1,793	2,920	6,939
1973	1,670	851	1,972	3,258	7,751
1974	1,844	933	2,164	3,584	8,525
		Projections			
1975	2,055	960	2,419	3,997	9,431
1976	2,384	1,037	2,655	4,430	10,504
1977	2,660	1,118	2,924	4,892	11,595
1978	2,941	1,201	3,200	5,343	12,684
1979	3,245	1,289	3,508	5,844	13,884
1980	3,555	1,379	3,850	6,338	15,128

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 12. Total S&T communication resource expenditures by participants in constant dollars: 1960-1980

[Millions of constant 1967* dollars]

Year	Scientist (Author)	Publisher	Library	Scientist (User)	Total
1960	384	175	615	1,118	2,292
1961	453	206	699	1,187	2,545
1962	471	272	751	1,273	2,768
1963	529	293	812	1,369	3,003
1964	543	319	860	1,438	3,175
1965	633	339	937	1,585	3,478
1966	734	367	1,010	1,719	3,831
1967	834	416	1,094	1,868	4,212
1968	903	456	1,185	1,948	4,493
1969	977	503	1,262	2,090	4,831
1970	1,045	536	1,318	2,184	5,083
1971	1,116	569	1,388	2,254	5,326
1972	1,178	613	1,443	2,350	5,584
1973	1,273	648	1,503	2,483	5,906
1974	1,275	645	1,496	2,478	5,893
		Projections			
1975	1,300	607	1,530	2,528	5,966
1976	1,413	615	1,574	2,626	6,226
1977	1,477	621	1,623	2,716	6,437
1978	1,528	624	1,662	2,775	6,588
1979	1,584	629	1,712	2,853	6,780
1980	1,631	633	1,766	2,908	6,941

* GNP Implicit Price Deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.

SOURCE: King Research, Inc., Center for Quantitative Sciences. Based on Table 11.

Table 13. Total S&T journal communication resource expenditures by participants: 1960-1980

[Millions of dollars]

Year	Scientist (Author)	Publisher	Library	Scientist (User)	Total
1960	204	88	331	654	1,277
1961	263	113	381	704	1,461
1962	269	172	412	763	1,616
1963	316	189	451	832	1,788
1964	319	208	483	887	1,897
1965	357	227	535	986	2,105
1966	452	250	592	1,090	2,384
1967	559	294	659	1,212	2,724
1968	636	342	739	1,325	3,042
1969	707	400	823	1,480	3,410
1970	794	460	907	1,628	3,789
1971	890	512	993	1,750	4,145
1972	989	574	1,065	1,863	4,491
1973	1,143	651	1,174	2,066	5,034
1974	1,264	720	1,290	2,285	5,559
		Projections			
1975	1,400	741	1,445	2,528	6,114
1976	1,655	805	1,590	2,796	6,852
1977	1,855	873	1,765	3,079	7,572
1978	2,061	944	1,941	3,358	8,304
1979	2,285	1,019	2,138	3,666	9,108
1980	2,512	1,097	2,364	3,970	9,943

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 14. Total S&T book communication resource expenditures by participants: 1960-1980

[Millions of dollars]

Year	Scientist (Author)	Publisher	Library	Scientist (User)	Total
1960	14	66	163	328	571
1961	21	70	188	352	631
1962	26	74	206	382	688
1963	33	77	226	416	752
1964	40	86	247	444	817
1965	43	91	274	493	901
1966	50	104	305	545	1,004
1967	49	118	343	606	1,116
1968	54	128	390	663	1,235
1969	58	143	435	740	1,376
1970	74	151	480	814	1,519
1971	85	166	534	875	1,660
1972	92	180	573	932	1,777
1973	102	190	628	1,033	1,953
1974	117	200	684	1,143	2,144
		Projections			
1975	124	206	758	1,264	2,352
1976	138	216	818	1,398	2,570
1977	152	226	889	1,540	2,807
1978	166	237	957	1,679	3,039
1979	182	247	1,026	1,833	3,288
1980	199	257	1,097	1,985	3,538

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 15. Total S&T report communication resource expenditures by participant: 1960-1980

[Millions of dollars]

Year	Scientist (Author)	Publisher	Library	Scientist (User)	Total
1960	-	-	22	-	22
1961	-	-	26	-	26
1962	-	-	28	-	28
1963	-	1	31	-	32
1964	-	1	33	-	34
1965	19	2	36	-	57
1966	31	2	41	31	105
1967	36	4	45	50	135
1968	38	4	53	38	133
1969	53	5	59	58	175
1970	65	5	65	70	205
1971	78	6	71	84	239
1972	95	8	77	125	305
1973	107	12	86	159	364
1974	125	12	95	156	388
		Projections			
1975	145	13	108	205	471
1976	168	16	120	235	539
1977	192	19	135	273	619
1978	216	20	151	306	693
1979	243	22	171	345	781
1980	271	25	197	384	877

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 16. Total S&T other media communication resource expenditures by participants: 1960-1980

[Millions of dollars]

Year	Scientist (Author)	Library	Total
1960	119	22	141
1961	118	25	143
1962	129	28	157
1963	134	31	165
1964	144	33	177
1965	178	36	214
1966	178	41	219
1967	190	45	235
1968	211	53	264
1969	247	59	306
1970	269	65	334
1971	289	71	360
1972	288	77	365
1973	318	82	400
1974	338	95	433
	Projections		
1975	386	108	494
1976	423	120	543
1977	462	135	597
1978	497	151	648
1979	536	171	707
1980	573	197	770

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 17. Total S&T book titles published: 1960-1980

Year	Titles Published	Year	Titles Published
1960	3,379	1971	12,595
1961	5,062	1972	13,042
1962	6,153	1973	13,522
1963	7,411	1974	14,442
1964	8,871	**Projections***	
1965	8,808	1975	14,277
1966	9,808	1976	14,753
1967	8,993	1977	15,228
1968	9,613	1978	15,798
1969	9,645	1979	16,274
1970	11,659	1980	16,884

* King Research, Inc., Center for Quantitative Sciences.

SOURCE: *The Bowker Annual of Library and Book Trade Information*, R. R. Bowker Company, 1962-1975.

Table 18. Total S&T book titles published as a function of number of scientists and engineers

Year	S&T Book Titles Published[1]	Scientists and Engineers[2] (000) (Lagged Three Years)
1963	7,411	1,159
1964	8,871	1,210
1965	8,808	1,272
1966	9,808	1,346
1967	8,993	1,396
1968	9,613	1,442
1969	9,645	1,501
1970	11,659	1,578
1971	12,595	1,649
1972	13,042	1,725
1973	13,522	1,797
1974	14,442	1,834

SOURCES:
[1] *The Bowker Annual of Library and Book Trade Information*, R. R. Bowker Company, 1962-1975.
[2] King Research, Inc., Center for Quantitative Sciences.

Table 19. Total S&T book titles published by six classifications: 1960-1980

Year	Agriculture	Sociology and Economics	Medicine	Science	Technology	Philosophy and Psychology
1960	78	754	520	1,089	698	240
1961	116	1,613	776	1,494	781	283
1962	142	2,059	952	1,743	931	327
1963	143	2,487	1,054	2,211	1,157	360
1964	143	3,272	1,211	2,738	1,125	383
1965	135	3,242	1,218	2,562	1,153	490
1966	144	3,482	1,446	2,958	1,333	446
1967	144	3,611	1,189	2,367	1,252	432
1968	125	4,070	1,277	2,407	1,262	473
1969	130	4,462	1,190	2,353	1,035	476
1970	133	5,912	1,476	2,358	1,141	640
1971	162	6,095	1,655	2,697	1,309	677
1972	195	6,415	1,839	2,586	1,425	582
1973	191	6,565	2,002	2,714	1,347	703
1974	196	6,640	2,281	3,049	1,593	684
		Projections*				
1975	200	6,858	1,932	3,148	1,507	660
1976	224	7,109	1,714	3,501	1,582	667
1977	213	7,285	1,680	3,576	1,765	631
1978	206	7,310	1,956	3,580	1,834	654
1979	248	7,413	1,929	3,859	1,957	628
1980	230	7,740	2,055	4,114	2,109	666

* King Research, Inc., Center for Quantitative Sciences.

SOURCE: *The Bowker Annual of Library and Book Trade Information*, Editions 8-20, R. R. Bowker Company, 1962-1975.

Table 20. Average number of copies sold per book title: 1960-1980

Year	Average Copies/Title	Year	Average Copies/Title
1960	2,394	1971	823
1961	1,697	1972	880
1962	1,419	1973	1,037
1963	1,082	1974	789
1964	1,053	**Projections**	
1965	1,019	1975	845
1966	1,029	1976	814
1967	1,279	1977	783
1968	1,260	1978	748
1969	1,385	1979	718
1970	975	1980	684

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 21. Average number of book copies sold per scientist or engineer

Year	Average Copies/S&E	Year	Average Copies/S&E
1960	6.98	1971	5.65
1961	7.10	1972	6.13
1962	6.86	1973	7.30
1963	5.96	1974	5.77
1964	6.70	**Projections**	
1965	6.23	1975	5.96
1966	6.73	1976	5.77
1967	7.29	1977	5.58
1968	7.35	1978	5.38
1969	7.75	1979	5.18
1970	6.33	1970	4.99

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 22. Average price per book: 1960-1980

Year	Average Price (Current $)	Average Price (Constant $)*
1960	8.54	9.72
1961	8.51	9.56
1962	8.84	9.83
1963	10.13	11.11
1964	9.67	10.45
1965	10.60	11.24
1966	10.86	11.15
1967	10.81	10.81
1968	11.12	10.69
1969	11.20	10.27
1970	13.92	12.10
1971	16.84	14.01
1972	16.45	13.24
1973	14.20	10.82
1974	18.43	12.74
Projections		
1975	17.89	11.32
1976	18.88	11.19
1977	19.93	11.06
1978	21.02	10.92
1979	22.19	10.83
1980	23.39	10.73

* King Research, Inc., Center for Quantitative Sciences. GNP Implicit Price Deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.

SOURCE: *The Bowker Annual of Library and Book Trade Information*, Edition 8-20, R.R. Bowker Company, 1962-1975.

Table 23. Average receipts per book title: 1960-1980

Year	Receipts/Title (Thousands Current $)	Receipts/Title (Thousands Constant $)*
1960	20.44	23.27
1961	14.44	16.23
1962	12.55	13.95
1963	10.96	12.03
1964	10.19	11.01
1965	10.72	11.37
1966	11.17	11.53
1967	13.82	13.82
1968	14.02	13.48
1969	15.51	14.23
1970	13.58	11.81
1971	13.87	11.54
1972	14.48	11.65
1973	14.73	11.22
1974	14.54	10.05
Projections		
1975	15.12	9.56
1976	15.37	9.11
1977	15.60	8.66
1978	15.72	8.16
1979	15.93	7.78
1980	16.00	7.34

* GNP Implicit Price Deflator (1975-1980) used to obtain 1967 Constant Dollars.

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 24. Price versus demand for S&T books

Year	Average Price (Constant $)[1]	Average Copies/ Title[2]
1960	8.54	2,394
1961	8.51	1,697
1962	8.84	1,419
1963	10.13	1,082
1964	9.67	1,053
1965	10.60	1,019
1966	10.86	1,029
1967	10.81	1,279
1968	11.12	1,260
1969	11.20	1,385
1970	13.92	975
1971	16.84	823
1972	16.45	880
1973	14.20	1,037
1974	18.43	789

SOURCES:
[1] *The Bower Annual of Library and Book Trade Information*, Editions 6-20, R.R. Bowker Company, 1962-1975.
[2] King Research, Inc., Center for Quantitative Sciences.

Table 25. Number of world and U.S. S&T journals published: 1960-1980

Year of Publication	No. of Journals Worldwide[1]	No. of Journals United States[2]
1960	18,800	6,335
1961	23,600	6,465
1962	23,100	6,614
1963	26,462	6,780
1964	25,573	6,950
1965	26,235	7,120
1966	30,110	7,290
1967	34,594	7,500
1968	37,182	7,670
1969	39,674	7,830
1970	40,431	7,920
1971	41,930	8,020
1972	44,676	8,170
1973	47,657	8,330
1974	49,440	8,460

SOURCES:
[1] 1961: Gottschalk, C.M. and Desmond, W.F., "Worldwide Census of Science and Technology Serials," *American Documentation*, 14:3 (July 1963).
1963-1974: Line, Maurice B. and Wood, D.N. "The Effect of a Large-Scale Photocopying Service on Journal Sales." *Journal of Documentation* (schuduled for publication).
[2] 1971: Davey, J.S. and Smith, E.S. "The Overseas Services of the British Library Lending Division." *Unesco Bulletin 29:5 (September-October 1975)*. *King Research, Inc., Center for Quantitative Sciences.*

Table 26. Number of scholarly S&T journals published in the U.S.: 1960-1980

Year	Scholarly S&T Journals Published
1960	1,492
1961	1,520
1962	1,553
1963	1,591
1964	1,628
1965	1,667
1966	1,702
1967	1,752
1968	1,797
1969	1,823
1970	1,837
1971	1,856
1972	1,887
1973	1,919
1974	1,945
Projections	
1975	2,013
1976	2,013
1977	2,041
1978	2,074
1979	2,106
1980	2,136

SOURCE: Journal Tracking Survey, King Research, Inc., Center for Quantitative Sciences.

Table 28. Number of scholarly S&T articles published: 1960-1980

Year	S&T Articles Published	Year	S&T Articles Published
1960	105,932	1971	145,458
1961	107,920	1972	147,162
1962	109,850	1973	150,311
1963	111,861	1974	150,572
1964	115,299	**Projections**	
1965	120,461	1975	155,345
1966	126,349	1976	158,863
1967	131,708	1977	161,795
1968	135,596	1978	165,312
1969	137,545	1979	168,830
1970	140,598	1980	172,348

SOURCE: Journal Tracking Survey, King Research, Inc., Center for Quantitative Sciences.

Table 27. Number of scholarly journals published in the nine fields of science: 1960-1980

Year	Physical Sciences	Mathematics	Computer Sciences	Environmental Sciences	Engineering	Life Sciences	Psychology	Social Sciences	Other Sciences
1960	68	32	15	31	250	577	47	498	46
1961	70	33	16	32	250	586	51	514	46
1962	73	34	16	33	251	580	55	519	46
1963	75	35	17	34	251	587	58	533	47
1964	77	36	18	35	251	592	62	546	47
1965	80	38	18	36	250	599	66	560	48
1966	83	39	19	37	250	606	69	573	48
1967	89	40	20	39	251	617	73	592	49
1968	98	42	21	40	249	627	78	613	49
1969	108	43	22	41	243	632	82	627	49
1970	116	44	22	42	234	634	86	638	49
1971	122	45	22	42	227	636	90	649	49
1972	121	46	23	43	227	639	93	657	49
1973	124	47	24	44	226	646	96	670	50
1974	125	48	24	45	225	650	99	679	50
Projections									
1975	133	51	26	47	228	669	105	702	52
1976	138	51	26	47	223	661	107	709	51
1977	144	51	27	48	222	663	110	722	50
1978	148	52	28	48	222	670	113	732	51
1979	152	53	28	49	222	674	117	744	51
1980	157	55	28	50	221	678	121	755	51

SOURCE: Journal Tracking Survey, King Research, Inc., Center for Quantitative Sciences.

Table 29. Number of scholarly S&T journal articles as a function of scientists and engineers

Year	Scholarly S&T Journal Articles[1]	Scientist and Engineers[2] (000)
1960	105,932	1,159
1961	107,920	1,210
1962	109,850	1,272
1963	111,861	1,346
1964	115,299	1,396
1965	120,461	1,442
1966	126,349	1,501
1967	131,708	1,578
1968	135,596	1,649
1969	137,545	1,725
1970	140,598	1,797
1971	145,458	1,834
1972	147,162	1,871
1973	150,311	1,923
1974	150,572	1,973

SOURCES:
[1] Journal Tracking Survey, King Research, Inc., Center for Quantitative Sciences.
[2] King Research, Inc., Center for Quantitative Sciences.

Table 30. Number of scholarly journal articles published in the nine fields of science: 1960-80

Year	Physical Sciences	Mathematics	Computer Sciences	Environmental Sciences	Engineering	Life Sciences	Psychology	Social Sciences	Other Sciences
1960	9,996	1,920	450	961	14,500	65,774	3,102	14,187	3,036
1961	10,500	2,046	512	1,024	15,000	67,160	3,366	14,740	3,036
1962	10,950	2,129	539	1,098	15,390	66,531	3,647	14,644	3,022
1963	11,489	2,257	621	1,177	15,904	65,719	3,758	15,532	2,990
1964	11,938	2,519	718	1,416	17,011	64,567	3,877	15,701	3,134
1965	12,698	2,853	760	1,775	18,163	66,730	4,077	14,655	3,194
1966	13,649	3,188	766	2,456	19,154	69,143	4,254	13,826	3,538
1967	14,872	3,484	792	3,421	19,910	69,393	4,354	14,544	3,946
1968	15,981	3,744	851	4,155	20,342	68,853	4,431	16,057	4,444
1969	16,397	3,985	918	4,340	20,203	69,208	4,623	16,559	4,938
1970	17,235	4,155	1,016	4,052	20,350	71,502	4,841	16,212	5,395
1971	18,673	4,244	1,091	3,781	21,260	74,014	4,894	15,726	5,755
1972	19,463	4,205	1,109	3,564	21,761	72,866	4,976	15,387	6,083
1973	19,407	4,107	1,090	3,359	22,328	74,062	5,242	15,514	6,454
1974	18,835	4,063	1,075	3,276	22,435	72,857	5,551	15,821	6,659
Projections									
1975	20,380	3,751	1,129	4,551	23,004	73,857	5,711	16,141	6,830
1976	21,000	3,804	1,152	4,780	23,876	74,168	5,845	16,051	7,178
1977	21,740	3,539	1,176	4,997	24,689	74,290	5,983	16,873	7,509
1978	22,350	3,572	1,197	5,205	25,695	77,196	6,153	16,119	7,825
1979	23,090	3,586	1,220	5,426	26,521	78,351	6,283	16,191	8,162
1980	23,830	3,670	1,243	5,626	27,489	79,126	6,443	16,454	8,467

SOURCE: Journal Tracking Survey, King Research, Inc., Center for Qunatitative Sciences.

Table 31. Number of scholarly S&T journal subscriptions: 1960-1980

Year	Foreign (000)	Institutional (000)	Individual (000)	Total (000)
1960	1,364	2,253	3,524	7,141
1961	1,519	2,461	3,851	7,831
1962	1,710	2,719	4,254	8,683
1963	1,845	2,877	4,501	9,223
1964	1,984	3,038	4,753	9,775
1965	2,146	3,227	5,047	10,420
1966	2,311	3,411	5,336	11,058
1967	2,533	3,673	5,744	11,950
1968	2,745	3,909	6,114	12,768
1969	2,924	4,091	6,399	13,414
1970	3,116	4,210	6,584	13,910
1971	3,250	4,268	6,675	14,193
1972	3,337	4,381	6,853	14,571
1973	3,436	4,487	7,018	14,941
1974	3,557	4,567	7,144	15,268
Projections				
1975	3,780	4,885	7,495	16,160
1976	3,940	5,045	7,725	16,710
1977	4,100	5,210	7,970	17,280
1978	4,260	5,376	8,214	17,850
1979	4,420	5,550	8,480	18,450
1980	4,590	5,721	8,729	19,040

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 32. Number of institutional journal subscriptions as a function of the number of scientists and engineers

Year	Total Number of Institutional Subscribers (000)	Number of Scientists and Engineers (000)
1960	2,253	1,159
1961	2,461	1,210
1962	2,719	1,272
1963	2,877	1,346
1964	3,038	1,396
1965	3,227	1,442
1966	3,411	1,501
1967	3,673	1,578
1968	3,909	1,649
1969	4,091	1,725
1970	4,210	1,797
1971	4,268	1,834
1972	4,381	1,871
1973	4,487	1,923
1974	4,567	1,973

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 33. Number of domestic journal subscriptions as a function of the number of scientists and engineers

Year	Total Number of Domestic Subscribers (000)	Number of Scientists and Engineers (000)
1960	5,777	1,159
1961	6,312	1,210
1962	6,973	1,272
1963	7,378	1,346
1964	7,791	1,396
1965	8,274	1,442
1966	8,747	1,501
1967	9,417	1,578
1968	10,023	1,649
1969	10,490	1,725
1970	10,794	1,797
1971	10,943	1,834
1972	11,234	1,871
1973	11,505	1,923
1974	11,711	1,973

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 34. Distribution of journal articles to scientists by individual and institutional subscriptions and reprints: 1960-1980

Year	Distribution of Journal Articles by Reprints	Distribution of Journal Articles by Institutional Subscriptions	Distribution of Journal Articles by Individual Subscriptions
1960	-	138	216
1961	-	144	226
1962	-	152	237
1963	-	150	234
1964	-	155	242
1965	-	161	252
1966	-	168	263
1967	-	175	273
1968	7.9	178	278
1969	8.0	178	278
1970	8.2	178	278
1971	8.6	182	284
1972	8.8	183	286
1973	8.8	182	285
1974	8.3	178	279
	Projections		
1975	8.1	188	289
1976	8.1	192	293
1977	8.1	193	294
1978	8.0	196	299
1979	8.0	197	301
1980	7.9	200	306

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 35. Average institutional, individual, and foreign subscription prices in current dollars: 1960-1980

Year	Individual Subscription Price[1] (Current $)	Foreign Subscription Price[1] (Current $)	Institutional Subscription Price[2] (Current $)
1960	5.27	6.01	7.88
1961	6.21	6.57	9.30
1962	8.71	8.48	12.73
1963	9.19	8.38	13.25
1964	9.67	8.39	13.77
1965	9.68	8.60	14.42
1966	9.70	9.33	15.07
1967	10.47	10.39	16.48
1968	11.25	11.66	17.89
1969	12.67	12.82	19.84
1970	14.10	14.22	21.78
1971	15.45	15.98	23.30
1972	16.80	18.23	24.82
1973	18.44	20.63	27.20
1974	20.08	21.90	29.57
	Projections		
1975	19.37	20.74	29.18
1976	20.31	21.82	30.60
1977	21.25	22.90	32.02
1978	22.19	23.98	33.44
1979	23.13	25.06	34.86
1980	24.07	26.14	36.28

SOURCES:
[1] King Research, Inc., Center for Quantitative Sciences.
[2] Journal Tracking Survey. King Research, Inc., Center for Quantitative Sciences.

Table 36. Average institutional, individual, and foreign subscription prices in constant dollars: 1960-1980

Year	Individual Subscription Price (Constant $)*	Foreign Subscription Price (Constant $)*	Institutional Subscription Price (Constant $)*
1960	6.00	6.84	8.97
1961	6.98	7.38	10.45
1962	9.68	9.43	14.15
1963	10.08	9.19	14.54
1964	10.45	9.06	14.87
1965	10.27	9.12	15.29
1966	10.01	9.63	15.55
1967	10.47	10.39	16.48
1968	10.82	11.21	17.20
1969	11.62	11.76	18.20
1970	12.26	12.36	18.94
1971	12.85	13.29	19.38
1972	13.52	14.67	19.97
1973	14.05	15.72	20.73
1974	13.88	15.14	20.44
Projections			
1975	12.25	13.12	18.46
1976	12.04	12.93	18.14
1977	11.80	12.71	17.78
1978	11.53	12.46	17.37
1979	11.29	12.23	17.02
1980	11.04	11.99	16.65

* GNP Implicit Price Deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.

SOURCE: King Research, Inc., Center for Quantitative Sciences. Based on Table 35.

Table 37. Institutional subscription price for nine fields of science: 1962-1974

Field of Science	1962 (Current $)	1964 (Current $)	1966 (Current $)	1968 (Current $)	1970 (Current $)	1972 (Current $)	1974 (Current $)
Physical Sciences	18.62	20.21	21.87	27.16	34.65	53.62	63.17
Mathematics	17.80	19.90	25.38	26.90	32.28	39.34	45.52
Computer Sciences	10.67	14.53	12.36	14.15	19.72	24.75	27.00
Environmental Sciences	12.65	14.37	16.33	19.22	25.28	30.46	37.61
Engineering	11.13	12.02	16.24	18.88	21.36	24.67	32.40
Life Sciences	13.08	14.16	15.25	19.65	26.20	29.62	34.66
Psychology	10.01	11.64	13.38	14.70	17.93	18.48	24.32
Social Sciences	13.36	13.75	13.75	14.96	15.99	16.30	17.53
Other Sciences	7.30	7.93	9.31	10.85	13.96	16.23	19.56
All Fields	12.73	13.77	15.07	17.89	21.78	24.82	29.57

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 38. Individual subscription price for nine fields of science: 1962-1974

Field of Science	1962 (Current $)	1964 (Current $)	1966 (Current $)	1968 (Current $)	1970 (Current $)	1972 (Current $)	1974 (Current $)
Physical Sciences	5.72	6.15	8.20	12.43	18.02	29.06	42.12
Mathematics	9.84	9.20	11.95	12.58	18.77	26.44	30.04
Computer Sciences	8.19	10.50	10.60	13.09	16.16	17.01	17.36
Environmental Sciences	9.33	9.93	10.45	13.40	15.40	19.50	18.93
Engineering	9.00	9.89	10.09	13.82	14.55	15.64	16.46
Life Sciences	12.04	13.03	12.72	16.74	20.92	24.05	28.97
Psychology	6.06	6.96	8.39	8.65	11.24	13.88	16.52
Social Sciences	6.10	6.56	6.56	5.38	6.73	7.83	9.32
Other Sciences	8.28	8.63	8.81	10.01	11.51	13.70	14.73
Average and All Fields	8.71	9.67	9.70	11.25	14.10	16.80	20.08

SOURCE: Journal Tracking Survey, King Research, Inc., Center for Quantitative Sciences.

Table 39. Average price per S&T article: 1960-1980

Year	Average Price per Article (Current $)	Average Price per Article (Constant $)*
1960	0.0742	0.0845
1961	0.0875	0.0983
1962	0.1226	0.1363
1963	0.1312	0.1440
1964	0.1363	0.1472
1965	0.1344	0.1426
1966	0.1311	0.1353
1967	0.1396	0.1396
1968	0.1501	0.1443
1969	0.1689	0.1549
1970	0.1855	0.1613
1971	0.1980	0.1647
1972	0.2153	0.1733
1973	0.2363	0.1801
1974	0.2608	0.1803
	Projections	
1975	0.2484	0.1571
1976	0.2571	0.1524
1977	0.2691	0.1494
1978	0.2774	0.1441
1979	0.2891	0.1411
1980	0.2971	0.1363

* GNP Implicit Price Deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 40. Average price per kiloword page: 1960-1980

Year	Average Price per Kiloword Page (Current $)	Average Price per Kiloword Page (Constant $)*
1960	0.0137	0.0156
1961	0.0162	0.0182
1962	0.0227	0.0253
1963	0.0239	0.0262
1964	0.0254	0.0274
1965	0.0248	0.0263
1966	0.0244	0.0252
1967	0.0259	0.0259
1968	0.0276	0.0265
1969	0.0306	0.0281
1970	0.0335	0.0291
1971	0.0363	0.0302
1972	0.0403	0.0324
1973	0.0440	0.0335
1974	0.0477	0.0330
	Projections	
1975	0.0460	0.0291
1976	0.0476	0.0282
1977	0.0508	0.0282
1978	0.0514	0.0267
1979	0.0535	0.0261
1980	0.0549	0.0252

* GNP Implicit Price Deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 41. Number of S&T reports processed by NTIS: 1965-1980

Year	S&T Reports Processed
1965	14,063
1966	21,747
1967	23,600
1968	24,190
1969	32,256
1970	37,539
1971	42,830
1972	49,482
1973	51,149
1974	56,358
1975	61,100
Projections*	
1976	65,929
1977	70,638
1978	75,347
1979	80,056
1980	84,766

* King Research, Inc., Center for Quantitative Sciences.

SOURCE: National Technical Information Service, Springfield, Virginia, 1975.

Table 42. Number of non-NTIS S&T reports processed by GPO: 1965-1980

Year	Estimated Number of S&T Reports (Non-NTIS)
1965	748
1966	713
1967	1,122
1968	935
1969	1,118
1970	1,005
1971	1,090
1972	1,646
1973	2,090
1974	1,961
Projections	
1975	2,084
1976	2,275
1977	2,405
1978	2,441
1979	2,519
1980	2,587

SOURCE: King Research, Inc., Center for Quantitative Sciences. (Study based on sample of items announced in *Monthly Catalog of U.S. Government Publications*, 1965-1974)

Table 43. Number of copies sold of NTIS reports as a function of number of reports (lagged one year)

Year	Number of Copies of NTIS Reports Sold (000)	Number of Reports (Previous Year)
1966	784	14,063
1967	761	21,747
1968	802	23,600
1969	1,122	24,190
1970	1,584	32,256
1971	1,703	37,539
1972	2,091	42,830
1973	2,638	49,482
1974	2,356	51,149
1975	2,999	56,358

SOURCE: National Technical Information Service, Springfield, Virginia, 1975.

Table 44. Paper copy and microfiche report sales at NTIS: 1966-1980

Year	Number of Microfiche Copies (000)	Number of Paper Copies Sold (000)
1966	283	501
1967	295	466
1968	349	453
1969	514	608
1970	869	715
1971	1,017	686
1972	1,421	670
1973	1,941	697
1974	1,599	757
1975	2,332	667
Projections*		
1976	2,260	768
1977	2,493	797
1978	2,717	823
1979	2,940	850
1980	3,164	876

* King Research, Inc., Center for Quantitative Sciences.

SOURCE: National Technical Information Service, Springfield, Virginia, 1975.

Table 45. Price for paper copy and microfiche reports at NTIS: 1966-1980

Year	Average Microfiche Copy Price (Current $)	Average Paper Copy Price (Current $)
1966	.35	1.55
1967	.49	2.38
1968	.45	2.62
1969	.62	3.27
1970	.38	3.15
1971	.50	3.37
1972	.66	3.71
1973	.56	4.89
1974	.69	5.15
1975	.60	5.07
Projections		
1976	.72	5.42
1977	.76	5.76
1978	.79	6.10
1979	.84	6.44
1980	.88	6.78

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 46. Average number of copies sold as a function of average price for scientific and technical reports sold by NTIS

Year	Average Price per Paper Copy Sold (Constant $)*	Average Number of Paper Copies Sold per Report
1966	1.60	35.6
1967	2.38	21.4
1968	2.52	19.2
1969	3.00	25.1
1970	2.74	22.2
1971	2.81	18.3
1972	2.98	15.6
1973	3.73	14.1
1974	3.56	14.8

* GNP Implicit Price Deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.
SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 47. Average number of copies sold for scientific and technical reports published by Government Printing Office: 1965-1980

Year	Copies Sold per GPO Technical Report
1965	1,209
1966	1,371
1967	1,746
1968	1,643
1969	1,523
1970	1,627
1971	1,778
1972	1,909
1973	1,688
1974	1,639
Projections	
1975	1,834
1976	1,874
1977	1,914
1978	1,954
1979	1,995
1980	2,035

SOURCE: King Research, Inc., Center for Quantitative Sciences. (Study based on sample of items announced in *Monthly Catalog of U.S. Government Publications*, 1965-1974).

Table 48. Price per page for scientific and technical reports published by Government Printing Office: 1965-1974

Year	Price Per Page (Cents)
1965	1.2
1966	1.1
1967	0.8
1968	0.6
1969	0.7
1970	0.9
1971	0.9
1972	0.9
1973	2.0
1974	1.8

SOURCE: King Research, Inc., Center for Quantitative Sciences. (Study based on sample of items announced in Monthly Catalog of U.S. Government Publications, 1965-1974).

Table 49. Number of published S&T conference proceedings

Year	Published S&T Conference Proceedings
1965	1,726
1966	1,762
1967	1,948
1968	2,121
1969	2,272
1970	2,367
1971	2,419

SOURCE: *The Directory of Published Proceedings*, Inter Dok Corporation, Harrison, New York, 1965-1973.

Table 50. The number of U.S. patent applications filed and issued: 1960-1980

Year	Patents Filed (000)	Patents Issued (000)	Year	Patents Filed (000)	Patents Issued (000)
1960	84.5	50.0	1971	111.1	81.8
1961	81.2	47.5	1972	105.3	78.2
1962	85.3	51.3	1973	109.6	78.6
1963	85.0	54.3	1974	108.0	79.9
1964	87.8	44.4		**Projections**	
1965	100.4	66.6	1975	115.6	85.5
1966	93.5	71.9	1976	117.8	88.0
1967	93.0	69.1	1977	120.0	90.6
1968	98.7	62.7	1978	122.2	93.2
1969	107.1	71.2	1979	124.5	95.7
1970	109.4	68.0	1980	126.7	98.3

* King Research, Inc., Center for Quantitative Sciences

SOURCE: Bureau of the Census, DOC. *Statistical Abstract of the United States*, 1960-1974.

Table 51. The number of dissertations published in science and technology 1960-1980

Year	Number of Dissertations Published	Year	Number of Dissertations Published
1960	3,387	1971	16,570
1961	4,119	1972	16,184
1962	4,203	1973	15,594
1963	4,816	1974	15,606
1964	6,349	**Projections**	
1965	8,865	1975	16,080
1966	9,584	1976	16,826
1967	11,601	1977	17,689
1968	12,084	1978	17,905
1969	14,422	1979	17,758
1970	15,885	1980	18,004

* King Research Inc., Center for Quantitative Sciences

SOURCE: *Dissertation Abstracts International*, Xerox-University Microfilm, Ann Arbor, Michigan, 1960-1975.

Table 52. Growth of U.S. scientific and technical literature forms: 1960-1980

Year	Journals[1]	Journal Articles[1]	Books[2]	Dissertations[3]	Technical Reports[4]	Patents[5]
1960	1,492	105,932	3,379	3,387	-	50,000
1961	1,520	107,920	5,062	4,119	-	47,500
1962	1,553	109,850	6,153	4,203	-	51,300
1963	1,591	111,861	7,411	4,816	-	54,300
1964	1,628	115,299	8,871	6,349	-	44,400
1965	1,667	120,461	8,808	8,865	-	66,600
1966	1,702	126,349	9,808	9,584	22,460	71,900
1967	1,752	131,708	8,993	11,601	24,722	69,100
1968	1,797	135,596	9,613	12,084	25,125	62,700
1969	1,823	137,545	9,645	14,422	33,374	71,200
1970	1,837	140,598	11,659	15,885	38,544	68,000
1971	1,856	145,458	12,595	16,570	43,920	81,800
1972	1,887	147,162	13,042	16,184	51,128	78,200
1973	1,919	150,311	13,522	15,594	53,239	78,600
1974	1,945	150,572	14,442	15,606	58,319	79,900
		Projections*				
1975	2,013	155,345	14,277	16,080	63,184	85,500
1976	2,013	158,863	14,753	16,826	68,204	88,000
1977	2,041	161,795	15,228	17,689	73,043	90,600
1978	2,074	165,312	15,798	17,905	77,788	93,200
1979	2,106	168,830	16,274	17,758	82,575	95,700
1980	2,136	172,348	16,884	18,004	87,353	98,300

* King Research, Inc., Center for Quantitative Sciences.

SOURCES:
[1] Journal Tracking Survey, King Research, Inc., Center for Quantitative Sciences.
[2] *The Bowker Annual of Library and Book Trade Information*, R. R. Bowker Company, 1962-1975.
[3] *Dissertation Abstracts International*, Xerox-University Microfilm, Ann Arbor, Michigan, 1960-1975.
[4] National Technical Information Service, Springfield, Virginia, 1975; and King Research, Inc., Center for Quantitative Sciences. (Study based on sample of items announced in *Monthly Catalog of U.S. Government Publications*, 1965-1974).
[5] Bureau of the Census, DOC, *Statistical Abstract of the United States*, 1960-1974.

Table 53. Number of items per scientist or engineer, by medium: 1960-1980

Year	Books (10^{-3})	Journals (10^{-3})	Journal Articles (10^{-3})	Dissertations (10^{-3})	Technical Reports (10^{-3})	Patents (10^{-3})
1960	2.92	1.29	91.40	2.92	-	43.14
1961	4.18	1.26	89.19	3.40	-	39.26
1962	4.84	1.22	86.36	3.30	-	40.33
1963	5.51	1.18	83.11	3.58	-	40.34
1964	6.36	1.17	82.59	4.55	-	31.81
1965	6.11	1.16	83.54	6.15	-	46.19
1966	6.53	1.13	84.18	6.39	15.67	47.90
1967	5.70	1.11	83.47	7.35	15.24	43.79
1968	5.83	1.09	82.23	7.33	19.35	38.02
1969	5.59	1.06	79.74	8.36	21.45	41.28
1970	6.49	1.02	78.24	8.84	21.45	37.84
1971	6.87	1.01	79.31	9.03	23.95	44.60
1972	6.97	1.01	78.65	8.65	27.33	41.80
1973	7.03	1.00	78.16	8.11	27.69	40.87
1974	7.32	.99	76.31	7.91	29.56	40.50
		Projections				
1975	7.05	.99	76.68	7.94	31.19	42.20
1976	7.09	.97	76.34	8.09	32.77	42.29
1977	7.12	.95	75.68	8.27	34.16	42.38
1978	7.20	.94	75.31	8.16	35.44	42.46
1979	7.22	.93	74.87	7.87	36.62	42.44
1980	7.30	.92	74.48	7.78	37.75	42.48

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 54. S&T communication resource expenditures for composition and recording, by medium: 1960-1980

[Millions of dollars]

Year	Journals	Books	Reports	Dissertations	Patents	Total
1960	204	14	-	5	114	337
1961	263	21	-	6	112	403
1962	269	26	-	7	122	424
1963	316	33	-	8	126	482
1964	319	40	-	11	133	503
1965	357	43	19	16	162	597
1966	452	50	31	18	160	711
1967	559	49	36	23	167	834
1968	636	54	38	25	186	939
1969	707	58	53	32	215	1,065
1970	794	74	65	37	232	1,202
1971	890	85	78	40	249	1,342
1972	989	92	95	41	247	1,464
1973	1,143	102	107	43	275	1,670
1974	1,264	117	125	48	292	1,844
Projections						
1975	1,400	124	145	51	335	2,055
1976	1,655	138	168	57	366	2,384
1977	1,855	152	192	64	398	2,660
1978	2,061	166	216	68	429	2,941
1979	2,285	182	243	72	464	3,245
1980	2,512	199	271	76	497	3,555

SOURCE: King Research, Inc., Center for Quantitative Sciences (1975-1980).

Table 55. Number of copies sold per item, by medium: 1960-1980

Year	Books	Journals[1]	Reports
1960	2,394	3,870	—
1961	1,697	4,150	—
1962	1,419	4,490	—
1963	1,082	4,640	—
1964	1,053	4,790	—
1965	1,019	4,960	—
1966	1,029	5,140	78.5
1967	1,279	5,380	110.1
1968	1,260	5,610	93.2
1969	1,385	5,750	84.6
1970	975	5,880	83.6
1971	823	5,900	82.9
1972	880	5,950	102.3
1973	1,037	6,000	115.9
1974	789	6,020	95.4
Projections			
1975	845	6,250	107.9
1976	914	6,340	106.9
1977	783	6,460	108.0
1978	748	6,550	106.8
1979	718	6,660	106.8
1980	684	6,760	106.5

[1] Domestic journal subscriptions used for calculations.

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 56. Copies sold per scientist and engineer, by medium: 1960-1980

Year	Books	Journals[1]	Reports
1960	6.98	4.98	—
1961	7.10	5.22	—
1962	6.86	5.48	—
1963	5.96	5.48	—
1964	6.70	5.58	—
1965	6.23	5.74	—
1966	6.73	5.83	1.18
1967	7.29	5.97	1.72
1968	7.35	6.08	1.42
1969	7.75	6.08	1.64
1970	6.33	6.01	1.79
1971	5.65	5.97	1.99
1972	6.13	6.00	2.80
1973	7.30	5.98	3.21
1974	5.77	5.95	2.82
Projections			
1975	5.96	6.11	3.37
1976	5.77	6.14	3.50
1977	5.58	6.16	3.69
1978	5.38	6.19	3.79
1979	5.18	6.22	3.91
1980	4.99	6.24	4.02

[1] Domestic journal subscriptions used for calculations.

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 57. S&T communication resource expenditures for reproduction and distribution by medium: 1960-1980

[Millions of dollars]

Year	Journals	Books	Reports	Total
1960	88.5	65.8	—	154.3
1961	113.2	69.6	—	182.8
1962	171.9	73.5	—	245.4
1963	189.2	77.3	0.7	267.2
1964	208.4	86.1	0.8	295.3
1965	227.4	90.7	2.0	320.1
1966	249.6	104.4	2.3	356.3
1967	294.1	118.4	4.0	416.5
1968	342.1	128.4	3.8	474.3
1969	400.3	142.5	4.9	647.7
1970	460.0	150.8	4.7	615.5
1971	512.3	166.4	5.5	684.2
1972	573.9	179.8	8.3	762.0
1973	650.8	189.7	11.9	851.4
1974	720.4	200.0	12.4	932.8
Projections				
1975	741.1	205.6	13.3	960.0
1976	805.3	215.9	15.9	1,037.1
1977	873.4	226.3	18.7	1,118.4
1978	944.2	236.6	20.1	1,200.9
1979	1,019.5	247.0	22.5	1,289.0
1980	1,097.0	257.2	24.9	1,379.1
Percent Change				
1960-65	157	38	-	108
1965-70	102	66	135	92
1970-75	61	36	183	56
1975-80	48	25	87	44

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 58. Price per copy by medium in current dollars: 1960-1980

Year	Books[1]	Journals[2]	Reports[2]
1960	8.54	5.27	—
1961	8.51	6.21	—
1962	8.84	8.71	—
1963	10.13	9.19	—
1964	9.67	9.67	—
1965	10.60	9.68	—
1966	10.86	9.70	1.55
1967	10.81	10.47	2.38
1968	11.12	11.25	2.62
1969	11.20	12.67	3.27
1970	13.92	14.10	3.15
1971	16.84	15.45	3.37
1972	16.45	16.80	3.71
1973	14.20	18.44	4.89
1974	18.43	20.08	5.15
Projections*			
1975	17.89	19.37	5.07
1976	18.88	20.31	5.42
1977	19.93	21.25	5.76
1978	21.02	22.19	6.10
1979	22.19	23.13	6.44
1980	23.39	24.07	6.78

* King Research, Inc., Center for Quantitative Sciences.

SOURCES:

[1] *The Bowker Annual of Library and Book Trade Information*, Editions 8-20, R.R. Bowker Company, 1962-1975. Price Data 1960-1970 based on Average Price per Volume Sold.

[2] King Research, Inc., Center for Quantitative Sciences. (Individual Subscription Price used for Journal Calculations and NTIS Paper copy used for report calculations.)

Table 59. Price per copy by medium in constant dollars: 1960-1980

Year	Books	Journals	Reports
1960	9.72	6.00	—
1961	9.56	6.98	—
1962	9.83	9.68	—
1963	11.11	10.08	—
1964	10.45	10.45	—
1965	11.24	10.27	—
1966	11.15	10.01	1.60
1967	10.81	10.47	2.38
1968	10.69	10.82	2.52
1969	10.27	11.61	3.00
1970	12.10	12.26	2.74
1971	14.01	12.85	2.81
1972	13.24	13.52	2.98
1973	10.82	14.05	3.73
1974	12.74	13.88	3.56
Projections			
1975	11.32	12.25	3.21
1976	11.19	12.04	3.21
1977	11.06	11.80	3.20
1978	10.92	11.53	3.17
1979	10.83	11.29	3.14
1980	10.73	11.04	3.11

* GNP Implicit Price Deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.

SOURCE: King Research, Inc., Center for Quantitative Sciences. Based on Table 58.

Table 60. Number of U.S. academic, special and public libraries

Year	Academic[1] Libraries[4]	Special[2] Libraries[4]	Public Libraries[3]	Total	ARL[4] Libraries	Federal[5] S&T Libraries
1960	2,031	3,972	7,204	13,207	49	—
1961	2,028	4,317	6,487	12,832	49	—
1962	2,024	4,662	5,770	12,456	49	—
1963	2,094	5,020	5,998	13,112	72	—
1964	2,163	5,377	6,626	14,166	74	—
1965	2,416	5,542	6,952	14,910	64	508
1966	2,668	5,706	7,278	15,652	64	—
1967	2,781	5,938	7,346	16,065	70	—
1968	2,894	6,169	7,415	16,478	71	—
1969	2,931	6,419	7,543	16,893	76	—
1970	2,968	6,669	7,671	17,308	76	—
1971	2,846	6,765	7,613	17,224	78	—
1972	2,723	6,861	7,555	17,139	78	995
1973	2,705	7,198	7,870	17,773	81	—
1974	2,686	7,536	8,185	18,407	82	—

[1] University, College and Junior College Libraries.
[2] Special, Law, Medical and Religious Libraries.

SOURCE:
[3] *The Bowker Annual of Library and Book Trade Information*, R.R. Bowker Company, 1961-1975.
[4] Association of Research Libraries, *American Library Statistics*, 1960-1972.
[5] National Center for Educational Statistics, *Survey of Federal Libraries*, 1972.

Table 61. U.S. S&T library expenditures in current dollars: 1960-1980

[Millions of Dollars]

Year	Academic[1] Libraries	Public[1, 2] Libraries	Federal[3] S&T Libraries	Total[4] S&T Libraries	58[5] Research Libraries
1960	79	40	[6]27	146	55
1961	92	42	[6]32	166	62
1962	107	44	[6]37	188	69
1963	124	47	[6]43	214	77
1964	138	52	[6]48	238	87
1965	160	55	53	268	101
1966	183	60	[6]64	307	113
1967	208	69	[6]76	353	134
1968	255	77	[6]88	420	150
1969	293	83	99	475	166
1970	325	92	103	520	190
1971	369	102	117	588	199
1972	398	108	133	639	205
1973	425	123	136	684	[6]215
1974	454	132	[6]153	739	[6]237
		Projections			
1975	494	140	170	804	256
1976	521	149	179	849	275
1977	556	158	190	904	287
1978	590	168	200	958	315
1979	618	177	208	1,003	336
1980	652	187	218	1,057	358

[1] King Research, Inc., Center for Quantitative Sciences.

SOURCES:
[1] *The Bowker Annual of Library and Book Trade Information*, R.R. Bowker Company, 1971, 1974, 1975.
[2] Goldhor, Herbert, "The Indices of American Public Library Statistics," April 1975 (unpublished paper).
[3] Vlannes, P. N., et. al., Report of the Ad Hoc Group *Federal Agency Obligations for Management, Processing and Transfer of Scientific and Technical Information, Data, and Technology*, Fiscal Years 1969-1973, Vol. III.
[4] King Research, Inc., Center for Quantitative Sciences.
[5] Dunn, Oliver C., et. al., *The Past and Likely Future of 58 Research Libraries, 1951-1980: A Statistical Study of Growth and Change*, 1970-71 edition.
[6] King Research, Estimate.

Table 62. U.S. S&T library expenditures in constant dollars: 1960-1980

[Millions of constant 1967 dollars]*

Year	Academic Libraries	Public Libraries	Federal S&T Libraries	Total S&T Libraries	58 Research Libraries
1960	90	45	31	166	63
1961	104	47	36	187	70
1962	118	50	41	209	77
1963	136	52	47	235	84
1964	149	56	52	257	94
1965	169	59	56	284	107
1966	189	62	66	317	117
1967	208	69	76	353	134
1968	245	74	85	404	144
1969	269	76	91	436	152
1970	282	80	90	452	165
1971	307	85	97	489	165
1972	320	87	107	514	165
1973	324	93	104	521	164
1974	314	91	106	511	164
		Projections			
1975	312	89	108	509	162
1976	309	88	106	503	163
1977	309	88	105	502	159
1978	307	87	104	498	164
1979	302	86	102	490	164
1980	299	86	100	485	164

* GNP Implicit Price Deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.

SOURCE: King Research, Inc., Center for Qunatitative Sciences Based on Table 61.

Table 63. S&T library expenditures per scientist or engineer: 1960-1980

Year	Expenditures per Scientist (Constant $)
1960	110
1961	117
1962	123
1963	126
1964	128
1965	133
1966	140
1967	145
1968	159
1969	163
1970	160
1971	172
1972	175
1973	171
1974	164
Projections	
1975	165
1976	164
1977	164
1978	163
1979	164
1980	164

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 64. U.S. S&T library material expenditures in current dollars: 1960-1980

[Millions of dollars]

Year	Public Libraries[1]	Federal S&T Libraries[2]	Academic Libraries[3]	Total S&T Material Expenditures[4]
1960	6	6	24	36
1961	7	7	28	41
1962	7	8	33	48
1963	7	10	41	58
1964	7	11	45	63
1965	7	12	56	75
1966	9	15	67	91
1967	10	17	78	105
1968	12	20	94	126
1969	14	23	107	144
1970	18	24	115	156
1971	18	27	124	169
1972	21	31	130	182
1973	21	31	142	193
1974	22	35	153	210
		Projections		
1975	25	38	157	220
1976	27	41	166	233
1977	29	43	175	247
1978	31	47	184	261
1979	33	49	193	275
1980	35	52	202	289

SOURCES:
[1] *The Bowker Annual of Library and Book Trade Information*, R.R. Bowker Company, 1971, 1974, 1975.
[2] Goldhor, Herbert. "The Indices of American Public Library Statistics," April 1975 (Unpublished Paper).
[3] Viannes, P.N., et. al., Report of the Ad Hoc Group: *Federal Agency Obligations for Management, Processing and Transfer of Scientific and Technical Information, Data, and Technology*. Fiscal Years 1969-1973, Vol. III.
[4] King Research, Inc., Center for Quantitative Sciences.

Table 65. U.S. S&T library material expenditures in onstant dollars: 1960-1980

[Millions of constant 1967 dollars]*

Library	Public Libraries	Federal S&T Libraries	Academic Libraries	Total S&T Material Expenditures
1960	7	7	28	41
1961	7	8	32	46
1962	8	9	36	53
1963	8	11	45	64
1964	8	12	49	68
1965	8	13	59	80
1966	9	15	69	94
1967	10	17	78	105
1968	11	19	91	121
1969	13	21	98	132
1970	15	21	100	136
1971	15	22	103	141
1972	17	25	105	146
1973	16	24	108	147
1974	16	24	106	145
Projections				
1975	16	24	100	139
1976	16	24	98	138
1977	16	24	97	137
1978	16	24	96	136
1979	16	24	94	134
1980	16	24	93	132

* GNP Implicit Price Deflator (1975-1980 NPA- used to obtain 1967 Constant Dollars.

SOURCE: King Research, Inc., Center for Quantitative Sciences. Based on Table 64.

Table 66. U.S. S&T library service expenditures: 1960-1980

[Millions of dollars]

Year	Service Expenditures (Current Dollars)	Service Expenditures (Constant Dollars)*
1960	110	125
1961	125	141
1962	140	156
1963	156	171
1964	175	189
1965	193	204
1966	216	223
1967	248	248
1968	294	283
1969	331	304
1970	364	316
1971	419	348
1972	457	368
1973	491	374
1974	529	366
Projections		
1975	584	370
1976	616	365
1977	657	365
1978	697	362
1979	728	356
1980	768	353

* GNP Implicit Price Deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 67. Number of item processed by U.S. national federation of abstracting and indexing services members: 1960-1980

[Thousands]

Year	Items
1960	588
1961	676
1962	713
1963	756
1964	795
1965	884
1966	986
1967	996
1968	1,135
1969	1,226
1970	1,257
1971	1,376
1972	1,449
1973	1,402
1974	1,443
Projections	
1975	1,590
1976	1,650
1977	1,720
1978	1,790
1979	1,850
1980	1,920

* King Research, Inc., Center for Quantitative Sciences.

SOURCE: National Federation of Abstracting and Indexing Services, *Member Service Statistics*, February 1974 and 1975.

Table 68. Estimated cost of organization and control of the S&T literature in current dollars: 1960-1980

[Millions of dollars]

Year	A&I Service Costs	Library Costs	Total Costs
1960	21	37	58
1961	25	42	67
1962	27	47	74
1963	30	52	81
1964	32	58	90
1965	37	64	101
1966	42	72	115
1967	45	83	128
1968	54	98	152
1969	62	110	172
1970	67	121	188
1971	78	140	218
1972	87	152	239
1973	89	164	253
1974	97	176	273
Projections			
1975	112	195	307
1976	122	205	327
1977	134	219	353
1978	146	232	378
1979	159	243	402
1980	173	256	429

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 69. Estimated cost of organization and control of the S&T literature in constant dollars: 1960-1980

[Millions of constant 1967 dollars]*

Year	A&I Service Costs	Library Costs	Total Costs
1960	24	42	66
1961	28	47	75
1962	30	52	82
1963	32	57	89
1964	35	63	98
1965	39	68	107
1966	44	74	118
1967	45	83	128
1968	52	94	146
1969	57	101	158
1970	58	105	163
1971	65	116	181
1972	70	122	192
1973	68	125	193
1974	67	122	189
Projections			
1975	71	123	194
1976	72	122	194
1977	74	122	196
1978	76	121	196
1979	77	119	196
1980	79	117	197

* GNP Implicit Price Deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.

SOURCE: King Research, Inc., Center for Quantitative Sciences. Based on Table 68.

Table 71. Cost of composition and recording in current and constant dollars: 1960-1980

[Millions of dollars]

Year	Cost (Current $)	Cost* (Constant $)
1960	337	384
1961	403	453
1962	424	471
1963	482	529
1964	503	543
1965	597	633
1966	711	734
1967	834	834
1968	939	903
1969	1,065	977
1970	1,202	1,045
1971	1,342	1,116
1972	1,464	1,178
1973	1,670	1,273
1974	1,844	1,275
Projections		
1975	2,055	1,300
1976	2,384	1,413
1977	2,660	1,477
1978	2,941	1,528
1979	3,245	1,584
1980	3,555	1,631

* GNP Implicit Price Deflator (1975-1980 NPA) used to obtain 1967 Constant Dollars.

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 72. Article identification methods

Year	Direct Identifications (000)	Indirect Identifications (000)	Total Identifications (000)
1973	720	872	1,722
1974	783	899	1,806
1975	835	831	1,819

SOURSE: Author Survey, King Research, Inc., Center for Quantitative Sciences.

Table 73. Percent of total article identifications made by direct article identification methods

Year	Library Subscription (%)	Preprint/ Reprint (%)	Individual Subscriptions (%)	Direct Total (%)
1973	9	12	21	42
1974	8	13	22	43
1975	7	14	25	46

SOURCE: Author Survey, King Research, Inc., Center for Quantitative Sciencee.

Table 74. Percent of total article identfications made by indirect article identification methods

Year	Abstract/ Index (%)	Colleagues' Reference (%)	Article, Book or Report Reference (%)	Indirect Total (%)
1973	9	15	27	51
1974	8	14	27	50
1975	7	11	29	46

SOURCE: Author Survey, King Research, Inc., Center for Quantitative Sciences.

Table 75. Article identification by field of science

	Physical Sciences (%)	Mathematics (%)	Computer Sciences (%)	Environmental Sciences (%)	Engineering (%)	Life Sciences (%)	Psychology (%)	Social Sciences (%)	Other Sciences (%)
Direct Identifications									
Subscription Copy	20.7	14.0	40.8	28.3	29.5	36.2	30.3	69.0	39.7
Preprint or Reprint	14.7	18.7	20.1	27.0	17.9	13.8	12.3	.3	10.3
Indirect Identifications									
Colleague Reference ..	17.1	24.4	.5	27.7	16.5	12.6	23.0	12.3	8.8
Article, Book or Report Reference	37.1	42.9	21.1	17.0	19.4	33.3	26.6	12.3	41.2
Abstract, Index	19.8	0.0	2.8	0.0	16.6	4.0	7.6	6.0	6.0

SOURCE: King Research, Inc., Center for Quantitative Sciences.

Table 76. Relative use of sources of access to cited articles, by year of citing article

[Thousands of articles cited, 3-year moving average]

Source of Access	Year of Citing Article		
	1973	1974	1975
	Articles	Articles	Articles
Library	732.6	791.4	783.2
Publisher	386.1	455.2	526.7
Colleague/ Office	206.6	202.1	156.5
Author	316.7	325.8	277.5

SOURCE: Author Survey, King Research, Inc., Center for Quantitative Sciences.

Table 77. Estimated total cost of assimilation of S&T literature: 1960-1980

[Millions of dollars]

Year	Books	Journals	Reports	Total
1960	327	654	-	981
1961	352	705	-	1,057
1962	382	763	-	1,145
1963	416	832	-	1,248
1964	444	887	-	1,331
1965	493	986	-	1,479
1966	545	1,090	31	1,666
1967	606	1,212	50	1,868
1968	663	1,325	38	2,026
1969	740	1,480	58	2,278
1970	814	1,628	70	2,512
1971	875	1,750	84	2,709
1972	932	1,863	125	2,920
1973	1,033	2,066	159	3,258
1974	1,143	2,285	156	3,584
	Projections			
1975	1,264	2,528	205	3,997
1976	1,398	2,796	235	4,430
1977	1,540	3,079	273	4,892
1978	1,679	3,358	306	5,343
1979	1,833	3,666	345	5,844
1980	1,985	3,970	384	6,338

SOURCE: King Research, Inc., Center for Quantitative Sciences.